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IS 13630-1 to 15 (2006): Ceramic Tiles - Methods of Test, Sampling and Basis for Acceptance [CED 5: Flooring, Wall Finishing and Roofing]



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IS 13630 (Parts 1 to 15) : 2006

भारतीय मानक
सिरैमिक टाइलें - परीक्षण पद्धतियाँ,
नमूने लेने तथा स्वीकार्यता का आधार
(पहला पुनरीक्षण)

Indian Standard

CERAMIC TILES — METHODS OF TEST,
SAMPLING AND BASIS FOR ACCEPTANCE

(First Revision)

ICS 91.100.23

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BUREAU OF INDIAN STANDARDS
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FOREWORD

This Indian Standard (Parts 1 to 15) (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Flooring, Wall Finishing and Roofing Sectional Committee had been approved by the Civil Engineering Division Council.

This standard was first published in various parts in 1992-93. This is the first revision; having all parts combined in one publication, of the standard in which the following major changes have been incorporated:

- a) As per the decision taken in the last meeting, the requirements of all the parts have been included in one volume and the revised standard has been brought in line with ISO 10545 (various parts).
- b) The requirements for determination of bulk density have been added in Part 2 and a few changes have been made in the requirements for determination of water absorption.
- c) A few modifications have also been made in Part 3.
- d) Requirements for determination of breaking strength have also been added in Part 6.
- e) Requirements for determination of glazing resistance tests have also been modified in Part 9.
- f) A new test for determination of impact resistance by measurement of co-efficient of restitution has been added as Part 14.
- g) IS 13711 : 1993 'Sampling and basis for acceptance' has been amalgamated with Part 15 of this standard.

In formulation of this standard considerable assistance have been derived from the following standards:

- ISO 10545-1 : 1995 Ceramic tiles — Part 1 : Sampling and basis for acceptance
- ISO 10545-2 : 1995 Ceramic tiles — Part 2 : Determination of dimensions and surface quality
- ISO 10545-3 : 1995 Ceramic tiles — Part 3 : Determination of water absorption, apparent porosity, apparent relative density and bulk density
- ISO 10545-4 : 2004 Ceramic tiles — Part 4 : Determination of modulus of rupture and breaking strength
- ISO 10545-5 : 1996 Ceramic tiles — Part 5 : Determination of impact resistance by measurement of coefficient of restitution
- ISO 10545-6 : 1995 Ceramic tiles — Part 6 : Determination of resistance to deep abrasion for unglazed tiles
- ISO 10545-7 : 1996 Ceramic tiles — Part 7 : Determination of resistance to surface abrasion for glazed tiles
- ISO 10545-8 : 1994 Ceramic tiles — Part 8 : Determination of linear thermal expansion
- ISO 10545-9 : 2004 Ceramic tiles — Part 9 : Determination of resistance to thermal shock
- ISO 10545-10 : 1995 Ceramic tiles — Part 10 : Determination of moisture expansion
- ISO 10545-11 : 1994 Ceramic tiles — Part 11 : Determination of crazing resistance for glazed tiles
- ISO 10545-12 : 1995 Ceramic tiles — Part 12 : Determination of frost resistance
- ISO 10545-13 : 1995 Ceramic tiles — Part 13 : Determination of chemical resistance
- ISO 10545-14 : 1995 Ceramic tiles — Part 14 : Determination of resistance to stains
- ISO 13006 : 1998 Ceramic tiles — Definitions, classification, characteristics and marking

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Indian Standard***CERAMIC TILES — METHODS OF TEST,
SAMPLING AND BASIS FOR ACCEPTANCE****PART 1 DETERMINATION OF DIMENSIONS AND SURFACE QUALITY***(First Revision)***1 SCOPE**

1.1 This standard (Part 1) covers methods for determining the dimensional characteristics (length, width, thickness, straightness of sides, rectangularity, surface flatness) and the surface quality of all ceramic tiles.

1.2 Tiles with area less than 400 mm² are excluded from measurements of length, width, thickness, straightness of sides, rectangularity, and surface flatness.

1.3 Spacer lugs, glaze bobs and other irregularities of the sides shall be ignored when measuring length, width, and straightness of sides, rectangularity if these are subsequently hidden in the joints after fixing.

2 MEASUREMENTS OF LENGTH AND WIDTH**2.1 Apparatus**

Vernier calipers or other suitable apparatus for linear measurement.

2.2 Test Specimens

Ten whole tiles in each type shall be tested.

2.3 Procedure

Measure each side of the tile under test at positions 5 mm from the corners. Measurements shall be made to the nearest 0.1 mm.

2.4 Expression of Results

The average dimension of square tiles is the average of four measurements. The average dimension of the sample is the average of 40 measurements. For oblong tiles, each similar pair of sides of a tile provides the appropriate average dimension of the tile, an average of two measurements. The average dimensions for length and width are the average of 20 measurements each.

2.5 Test Report

The test report shall contain the following:

- a) Description of the tiles;

- b) All measurements of length and width;
- c) Average size of each test specimen for square tiles; and the average length and width for each oblong tile;
- d) Average size of 10 test specimens for square tiles and the average length and width of oblong tiles;
- e) Deviation in percent of the average size of each tile (2 or 4 sides) from the work size; and
- f) Deviation in percent of the average size of each tile (2 or 4 sides) from the average size of the 10 test specimens (20 or 40 sides).

3 MEASUREMENTS OF THICKNESS**3.1 Apparatus**

Micrometer screw gauge with anvils of 5 mm to 10 mm diameter, or other suitable apparatus.

3.2 Test Specimens

Ten whole tiles in each type shall be tested.

3.3 Procedure

3.3.1 For all tiles except split tiles, draw diagonals between the corners and measure the thickness at the thickest point within each of the four segments. Measure the thickness of each tile under test in four positions to an accuracy of 0.1 mm.

3.3.2 For split tiles, draw four lines at right angles across the extruded projections at distance of 1/8, 3/8, 5/8, 7/8 of the length measured from the end. Measure the thickness at the thickest point on each line.

3.4 Expression of Results

For all tiles the average thickness of each individual tile is the average of four measurements. The average thickness of the sample is the average of 40 measurements.

3.5 Test Report

The test report shall contain the following:

- a) Description of the tiles;

- b) All measurements of thickness;
- c) Average thickness of each test specimen; and
- d) Deviation in percent of the average thickness of each tile (2 or 4 sides) from the work size thickness.

4 MEASUREMENTS OF STRAIGHTNESS OF SIDES

4.1 Terminology

4.1.1 For the purpose of measurement of straightness of ceramic tiles according to this standard, the following definitions shall apply.

4.1.2 *Straightness of Sides* — Defined as the deviation from straightness of the centre of the side in the plane of the tile. The measurement is only relevant to the straight sides of tiles.

4.2 Apparatus

4.2.1 An apparatus as shown in Fig. 1, or other suitable apparatus such as steel square. The dial gauge (A) is used for measuring the straightness of sides.

4.2.2 A calibrating plate made of steel of accurate dimensions and with straight flat sides.

4.3 Test Specimens

Ten whole tiles in each type shall be tested.

4.4 Procedure

4.4.1 Select an apparatus of the appropriate dimensions so that, when a tile is placed in the apparatus, the locating studs are 5 mm from the each corner of the side being measured.

4.4.2 Fit the appropriate calibrating plate exactly into position in the instrument and adjust the dial gauge reading to a suitable known value.

4.4.3 Remove the calibrating plate, place the proper surface of the tile on the locating studs in the apparatus and record the dial gauge reading in the centre of the side. Rotate the tile, if square, to obtain four measurements. Repeat this procedure for each tile. In the case of oblong tiles, use separate instruments of the appropriate dimensions to measure lengths and width. Measure to an accuracy of 0.1 mm.

4.5 Test Report

The test report shall contain the following:

- a) Description of the tiles;
- b) All measurements of straightness of sides; and
- c) Maximum deviation from straightness in percent, related to the corresponding work sizes.

5 MEASUREMENT OF RECTANGULARITY

5.1 Terminology

5.1.1 For the purpose of measurement of rectangularity of ceramic tiles according to this standard, the following definition shall apply.

5.1.2 *Deviation from Rectangularity* — If a corner of the tile is placed against the angle of an accurate calibrating plate, deviation in percent from rectangularity is defined as:

$$\frac{\delta}{L} \times 100$$

where

L = length of the adjacent sides of the tile, and

δ = deviation of the outer corner of the side of the tile (measured 5 mm from the corner) from the inner side of the calibrating plate.

5.2 Apparatus

5.2.1 An apparatus as shown in Fig. 1, or other suitable apparatus such as steel square. The dial gauge (B) is used for measuring the rectangularity of sides.

5.2.2 A calibrating plate, made of steel of accurate dimensions and with straight flat sides.

5.3 Test Specimens

Ten whole tiles in each type shall be tested.

5.4 Procedure

5.4.1 Select an apparatus of the appropriate dimensions so that, when a tile is placed in the apparatus, the locating studs are 5 mm from the each corner of the side being measured. The plunger of the dial gauge (B) shall also be 5 mm from the corner of the tile on the side being measured.

5.4.2 Fit the appropriate calibrating plate exactly into position in the instrument and adjust the dial gauge reading to a suitable known value.

5.4.3 Remove the calibrating plate, place the proper surface of the tile on the locating studs in the apparatus and record the dial gauge reading 5 mm from the corner. Rotate the tile, if square, to obtain four measurements. Repeat this procedure for each tile. In the case of oblong tiles, use separate instruments of the appropriate dimensions to measure lengths and width. Measure to an accuracy of 0.1 mm.

5.5 Expression of Results

Rectangularity shall be expressed as a percentage of the length and width for oblong tiles; and the size for square tiles.

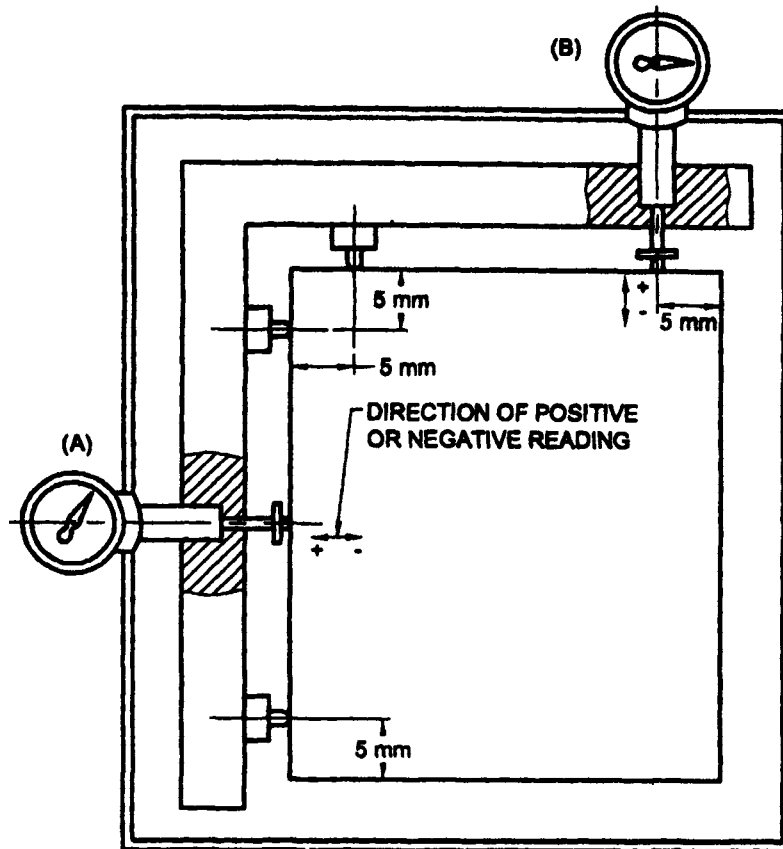


FIG. 1 APPARATUS FOR MEASUREMENT OF STRAIGHTNESS OF SIDES AND RECTANGULARITY

5.6 Test Report

The test report shall contain the following:

- Description of the tiles;
- All measurements of rectangularity; and
- Maximum deviation from rectangularity in percent, related to the corresponding work sizes.

6 MEASUREMENTS OF SURFACE FLATNESS (CURVATURE AND WARPAGE)

6.1 Terminology

6.1.1 For the purpose of measurement of surface flatness (curvature and warpage) of ceramic tiles according to this standard, the following definitions shall apply.

6.1.2 Surface Flatness — Defined by measurements in three positions on the surface of tiles. Tiles that have relief on the proper surface preventing measurements on that surface shall, where possible, be measured on the back.

6.1.3 Centre Curvature — The departure of the centre of a tile from the plane in which three of the four corners lie.

6.1.4 Edge Curvature — The departure of the centre of one edge of a tile from the plane in which three of the four corners lie.

6.1.5 Warpage — The departure of the fourth corner of a tile from the plane in which three of the four corners lie.

6.2 Apparatus

6.2.1 For tiles larger than 40 mm × 40 mm the apparatus given in 6.2.1.1 and 6.2.2.2 shall be used.

6.2.1.1 An apparatus as shown in Fig. 2, or any other suitable instrument. Although only one dial gauge is shown in the figure, there are three on the instrument, located at the centre of one side, at the centre of the tile and at one corner. To measure smooth-surfaced tiles the support studs are 5 mm in diameter. In order to obtain meaningful results for other tile surfaces, suitable support studs shall be used.

6.2.1.2 True flat calibrating plate of metal or glass and at least 10 mm thick for the apparatus described in 6.2.1.1.

6.2.2 For tiles of dimensions 40 mm × 40 mm or less the apparatus given in 6.2.2.1 and 6.2.2.2 shall be used.

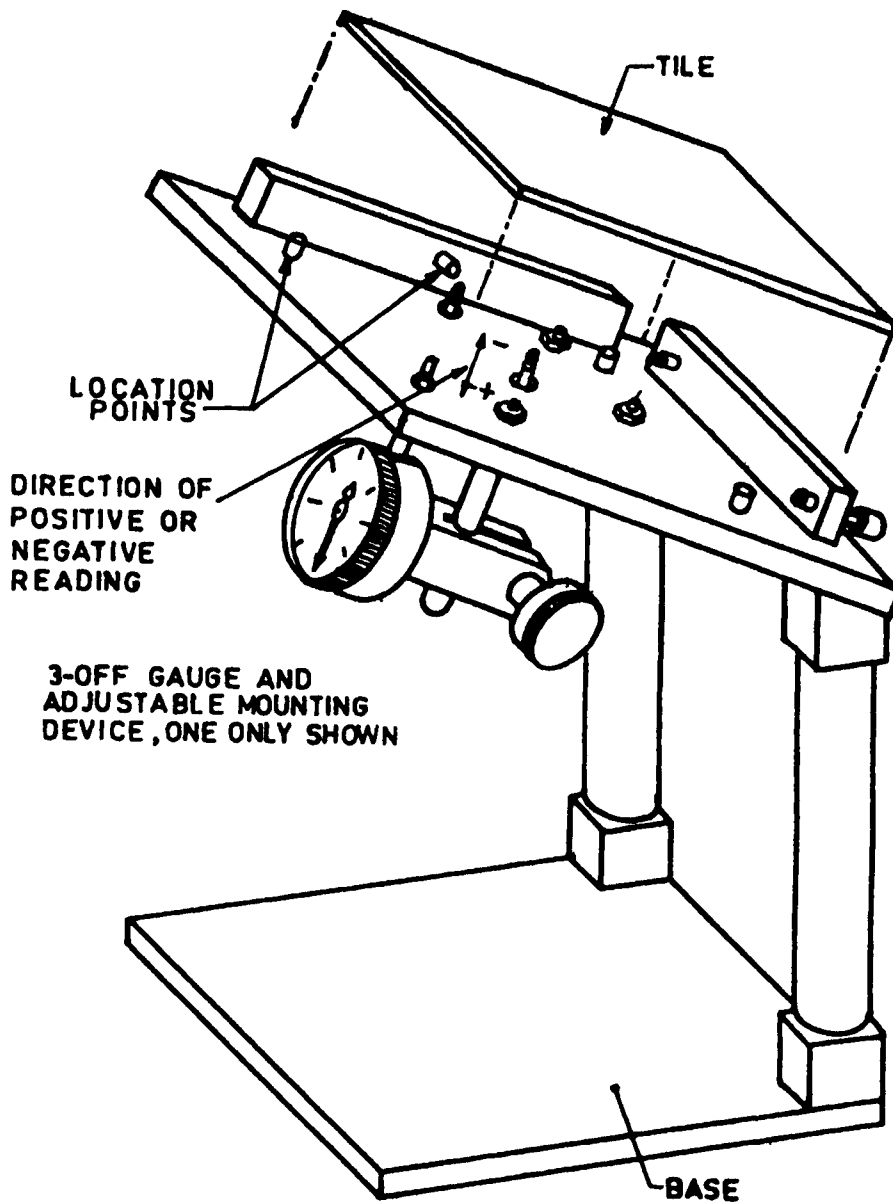


FIG. 2 APPARATUS FOR MEASUREMENT OF SURFACE FLATNESS

6.2.2.1 Metal straightedge

6.2.2.2 Thickness feeler gauges

6.3 Test Specimens

Ten whole tiles in each type shall be tested.

6.4 Procedure

6.4.1 For Tiles Larger Than 40 mm × 40 mm

6.4.1.1 Select an apparatus of the appropriate size and place the corresponding calibrating plate exactly into positions on top of the three accurately positioned studs.

6.4.1.2 The centre of each stud is 10 mm from the side

of the tile, and the two outer dial gauges are 10 mm from the sides of the tile.

6.4.1.3 Adjust the three dial gauges to a suitable known value.

6.4.1.4 Remove the calibrating plate, place a tile on the apparatus with proper surface of the tile downwards and record the three dial gauge reading in the centre of the side. Rotate the tile, if square, to obtain four measurements of each properties. Repeat this procedure for each tile. In the case of oblong tiles, use separate instruments of the appropriate dimensions. Record the maximum centre curvature, edge curvature and warpage for each tile. Measure to an accuracy of 0.1 mm.

6.4.2 For Tile Dimension of 40 mm × 40 mm or Less

6.4.2.1 In order to measure edge curvature, place a straightedge across the edges and measure the gap under the straightedge by means of the feeler gauges. Determine centre curvature in the same manner but along diagonals.

6.4.2.2 There shall be no warpage measurements.

6.5 Expression of Results

6.5.1 Centre curvature is expressed as a percentage of the length of the diagonal.

6.5.2 Edge curvature is expressed as percentage of the length and width, for oblong tiles and percentage of the size for square tiles. Warpage is expressed as a percentage of the length of the diagonal.

6.5.3 Measurements for tiles with spacer lugs shall be expressed in mm.

6.6 Test Report

The test report shall contain the following:

- a) Description of the tiles;
- b) All measurements of centre curvature;
- c) All measurements of edge curvature;
- d) All measurements of warpage;
- e) Maximum centre curvature, in percentage, related to the diagonal calculated from work size;
- f) Maximum edge curvature, in percentage, related to the corresponding work size; and
- g) Maximum warpage, in percentage related to the diagonal calculated from work size.

7 SURFACE QUALITY

7.1 Surface Defects and Intentional Effects

7.1.1 Criteria for assessing the surface quality of glazed, engobed and unglazed tiles are as follows:

- a) Cracks,
- b) Crazing,
- c) Short glazing,
- d) Unevenness,
- e) Depressions,
- f) Holes,
- g) Glaze devitrification,
- h) Specks and spots,
- j) Under glaze faults,
- k) Decorating faults,

- m) Shading,
- n) Nipped edges, and
- p) Nipped corners.

7.1.2 In order to judge whether an intentional decorative effect is acceptable or is a defect; see the relevant clause of the product standard. Cracks, nipped edges and nipped corners cannot be intentional effects.

7.2 Apparatus

7.2.1 *Fluorescent Lighting of Colour Temperature 6 000 K to 6 500 K*

7.2.2 *Meter Rule or Other Suitable Means of Measuring Distance*

7.2.3 *Light Meter*

7.3 Test Specimens

At least 1 m² with a minimum of 30 tiles shall be tested.

7.4 Procedure

7.4.1 Place the tiles with the proper surface under observation so that they can be viewed normally at a distance of 1 m. Illuminate them with an even light intensity of 300 lux at the surface of the tiles and check the light intensity at the centre and each corner of the area of tiles under test.

7.4.2 View the tiles with naked eye (with the aid of a spectacle, if usually worn).

7.4.3 Preparation of the test area and the viewing of the test shall not be performed by the same person.

7.4.4 Intentional effects in the surface shall not be regarded as defects.

7.5 Expression of Results

Surface quality is expressed as the percentage of tiles without defects.

7.6 Test Report

The test report shall contain the following:

- a) Description of the tiles;
- b) Number of tiles tested including the area of tiles tested;
- c) Assessment criteria used; and
- d) Percentage of tiles without defects.

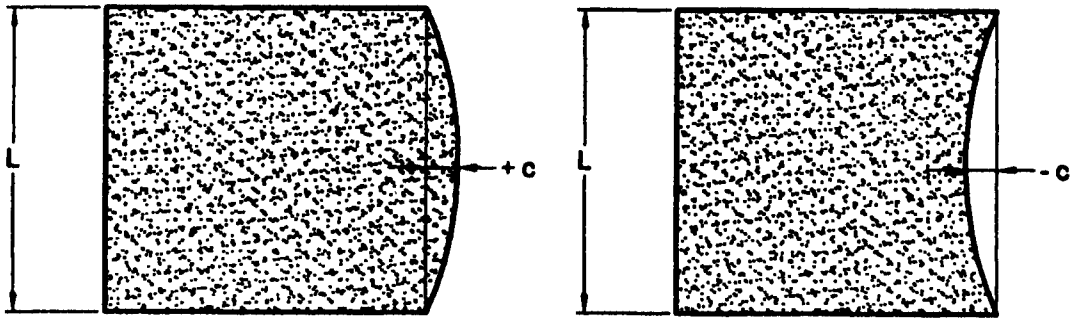


FIG. 3 STRAIGHTNESS OF SIDES; DEVIATION FROM STRAIGHTNESS: c/L

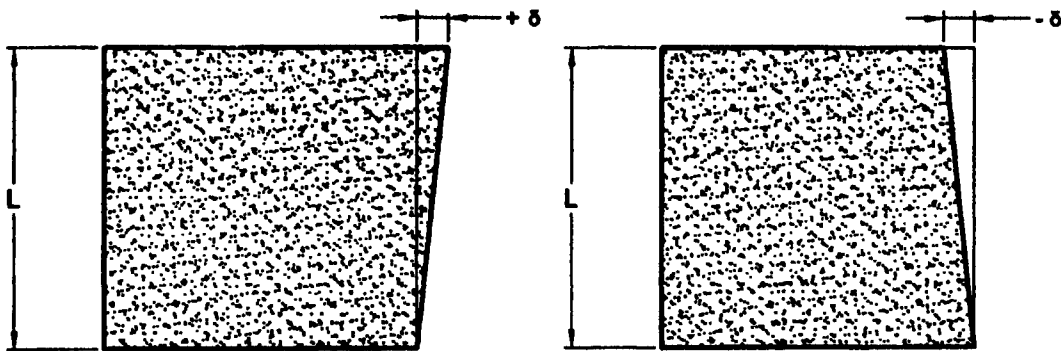


FIG. 4 RECTANGULARITY; DEVIATION FROM RECTANGULARITY δ/L

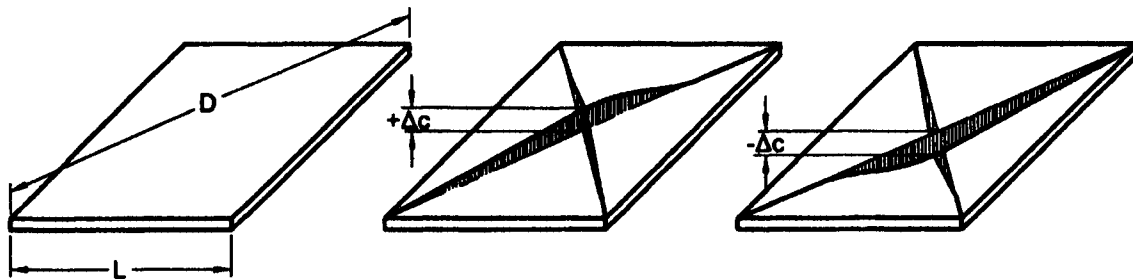


FIG. 5 CENTRE CURVATURE ($\Delta c/D$)

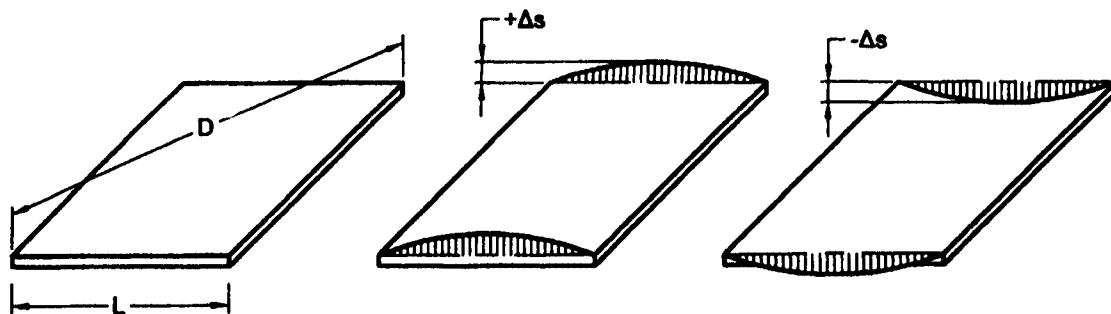


FIG. 6 EDGE CURVATURE ($\Delta s/L$)

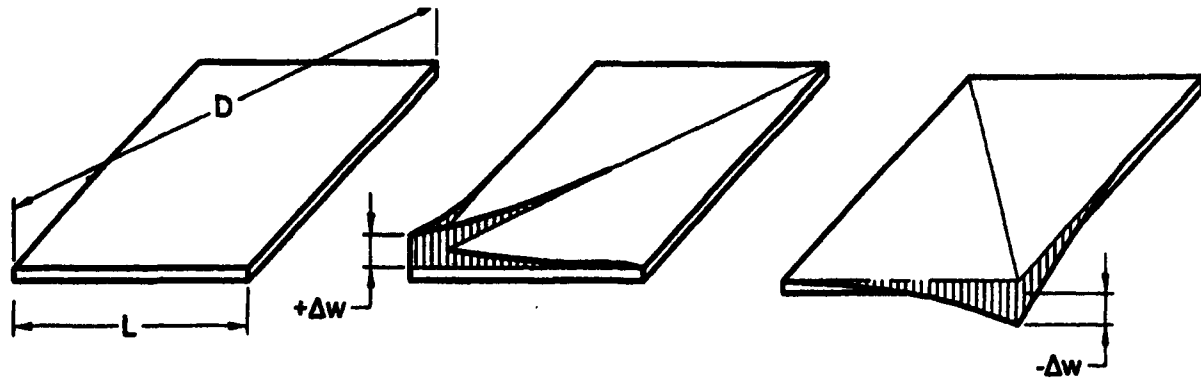


FIG. 7 WARPAGE ($\Delta w/D$)

*Indian Standard***CERAMIC TILES — METHODS OF TEST,
SAMPLING AND BASIS FOR ACCEPTANCE****PART 2 DETERMINATION OF WATER ABSORPTION AND BULK DENSITY***(First Revision)***1 SCOPE**

This standard (Part 2) covers methods of test for determining the water absorption of all ceramic tiles.

2 TERMINOLOGY

2.1 For the purpose of this standard, the following definition shall apply.

2.2 **Water Absorption** — The increase in mass (expressed as a percentage of the mass of the dry material) of tiles which after determination of the dry mass are placed under water, then boiled and, afterwards, cooled during specified times while still completely immersed, taken out of the water and reweighed after removing excess of water.

3 APPARATUS

3.1 **Drying Oven** — Capable of operation at about 110°C.

3.2 **Heating Apparatus** — Constructed of suitable inert material, in which the boiling will take place.

3.3 **Source of Heat**

3.4 **Balance** — Accurate to 0.01 percent of the mass of a test specimen.

3.5 **De-ionized or Distilled Water**

3.6 **Desiccator**

3.7 **Chamois Leather**

3.8 **Wire Loop, Halter, Basket** — Capable of supporting specimens under water for making suspended mass measurements.

4 TEST SPECIMENS

4.1 A sample for each type of tile under test shall consist of 10 whole tiles.

4.2 If the proper surface area of each individual tile is greater than 0.04 m², then only 5 whole tiles shall be used for the tests.

4.3 When the mass of each individual tile is below 50 g, a sufficient number of tiles shall be taken

so that each test specimen reaches a mass of 50 g to 100 g.

4.4 Tiles with sides larger than 200 mm may be cut up, but all pieces shall be included in the measurement. With polygonal and other non-rectangular tiles, the length and width shall be those of the enclosing rectangles.

5 PROCEDURE**5.1 Water Impregnation**

5.1.1 Dry the tiles in the oven at 110 ± 5°C until constant mass is reached, that is, when the difference between two successive weighing at intervals of 24 h is less than 0.1 percent.

5.1.2 Cool the tiles in the desiccator over silica gel or other suitable desiccant, but not an acid, until cooled to room temperature.

5.1.3 Weigh each tile and record the results of the corresponding accuracy shown in Table 1.

Table 1 Tile Mass: Accuracy of Measurement

Sl No.	Mass of Tiles g (1)	Accuracy of Measurements g (2)
i)	0 to 100	0.02
ii)	101 to 500	0.05
iii)	501 to 1 000	0.25
iv)	1 001 to 3 000	0.50
v)	Above 3 000	1.00

5.1.4 Place the tiles vertically, with no contact between them, in water in the heating apparatus/water bath so that there is a depth of 50 mm water above and below the tiles. Maintain the water level of 50 mm above the tiles throughout the test.

5.1.5 Heat the water until boiling and continue to boil for 2 h. Then remove the source of heat and allow the tiles to cool, still completely immersed in this water overnight.

5.1.6 Remove the surface water from the tile pieces by chamois leather.

5.1.7 Immediately after this procedure weigh each tile and record the results to the same accuracy as for the dry state.

5.2 Suspended Weight

After water impregnation of the test specimens, determine to the nearest 0.01 g the mass m_3 , of each specimen while suspended in water. Perform the weighing by placing the specimen in the wire loop, halter, or basket (*see* 3.8) that is suspended from one arm of the balance. Before actually weighing, counterbalance the scale with the wire loop, halter, basket in place and immerse in water to the same depth as is used when the specimens are in place.

6 EXPRESSION OF RESULTS

6.1 Water Absorption

6.1.1 For each tile, calculate the water absorption as a percentage of the dry mass using the expression:

$$\frac{m_2 - m_1}{m_1} \times 100$$

where

- m_1 = mass of the dry tile; and
- m_2 = mass of the wet tile.

6.1.2 The results shall be given to the first decimal place.

6.1.3 Calculate the average water absorption of the sample as the average of the individual results.

6.2 Bulk Density

6.2.1 Bulk density, B , in g/cm^3 , of a specimen is the quotient of its dry mass divided by the exterior volume, including pores. Calculate the bulk density as follows:

$$B = (m_1/V)$$

where

- m_1 = mass of the dry tile;
- V = exterior volume, in cm^3 : ($m_2 - m_3$); and
- m_3 = mass of suspended tile impregnated by boiling water method.

NOTE — For determination of bulk density by boiling water method, the specimen size should not be more than 0.01 m^2 (100 mm \times 100 mm) to facilitate proper weighing of tile under suspended conditions by boiling water method.

6.3 Test Report

The test report shall contain the following:

- a) Description of the tiles;
- b) Water absorption and bulk density of each individual tile; and
- c) Average water absorption and bulk density.

Indian Standard

**CERAMIC TILES — METHODS OF TEST,
SAMPLING AND BASIS FOR ACCEPTANCE**

**PART 3 DETERMINATION OF MOISTURE EXPANSION USING
BOILING WATER — UNGLAZED TILES**

(First Revision)

1 SCOPE

This standard (Part 3) covers methods of test for determining the moisture expansion of unglazed ceramic tiles.

2 TERMINOLOGY

2.1 For the purpose of this standard, the following definition shall apply.

2.2 Moisture Expansion Using Boiling Water — The difference between the means of measurements made on test specimens before and after subjecting them to boiling water. It is expressed as l/L , where l is the expansion after treatment in boiling water and L is the initial length.

3 APPARATUS

3.1 Direct reading gauge with a minimum travel of 10 mm and an accuracy of at least 0.01 mm.

3.2 Reference bars of nickel steel (invar) of the approximate lengths of the test specimens.

3.3 Kiln

3.4 Vernier calipers or other suitable apparatus, for linear measurement to the nearest 0.5 mm.

3.5 An apparatus for maintaining the specimens in boiling water for 24 h.

4 TEST SPECIMENS

4.1 Sample for each type of tile under test shall consist of seven whole tiles. Cut a test specimen from the centre of each tile of the greatest possible length of up to 100 mm with a minimum width of 35 mm and the thickness that of the tile.

4.2 In the case of extruded tile the length of the test specimens shall be in the direction of the extrusion.

4.3 Prepare the ends of the test specimens as required for the adopted measuring device.

5 PROCEDURE

5.1 Refiring

5.1.1 If the test specimens become wet during cutting, keep them for 24 h at room temperature.

5.1.2 Refire the test specimens in a kiln, with a temperature rise of 150°C/h and a 2 h soak at 600°C.

5.1.3 Allow the test specimens to cool inside the kiln for at least 20 h, remove them when the temperature falls to $70 \pm 10^\circ\text{C}$ and then keep them at room temperature for at least 20 h in a desiccator.

5.1.4 Measure the test specimens twice with 3 h between measurements.

5.1.5 Record the length of each test specimen relative to the length of the invar reference bar in order to eliminate possible variations of the measuring apparatus.

5.1.6 Determine the initial length of each test specimen to the nearest 0.5 mm.

5.2 Boiling Water Treatment

5.2.1 Immerse the test specimens in boiling water for 24 h consecutively, ensuring that there is at least 50 mm height of water above and the test specimen do not touch each other or touch the base and sides.

5.2.2 Remove the test specimens and allow them to cool at room temperature, measure them after 1 h and again after a further 3 h.

5.2.3 Record the measurement as in 5.1.

6 EXPRESSION OF RESULTS

6.1 For each test specimens determine the mean of the two measurements prior to treatment in boiling water, the mean of the two measurements after boiling water treatment and then determine the difference between the two mean values.

6.2 The moisture expansion, in mm/m is calculated from $l/L \times 1\,000$.

7 TEST REPORT

The test report shall contain the following:

- a) Description of the tiles; and
- b) Moisture expansion of each test specimen.

*Indian Standard***CERAMIC TILES — METHODS OF TEST,
SAMPLING AND BASIS FOR ACCEPTANCE****PART 4 DETERMINATION OF LINEAR THERMAL EXPANSION***(First Revision)***1 SCOPE**

This standard (Part 4) covers a method of test for determining the coefficient of linear thermal expansion of all ceramic tiles.

2 PRINCIPLE

The coefficient of linear thermal expansion is determined for the temperature range from ambient temperature to 100°C.

3 APPARATUS**3.1 Suitable Calibrated Thermal Expansion Apparatus**

The apparatus should be capable of heating at the rate of 3°C/min with uniform distribution of heat to a test specimen. Certain types of apparatus require a soaking time at 100°C.

3.2 Vernier Callipers

3.3 Drying Oven — Capable of operating at 110 ± 5°C.

3.4 Desiccator**4 TEST SPECIMENS**

4.1 Two test specimens shall be cut at right angles from the central portion of one tile so that their lengths are suitable for the apparatus.

4.2 The end of the test specimens shall be ground flat and parallel.

4.3 The test specimens are ground to make the length of specimen equal to 25.4 ± 1 mm and diameter equal to 10 ± 1 mm. Alternatively, the size of the test specimen should be according to the requirement of the apparatus.

4.4 In the case of glazed tiles, the glaze shall be ground off the test specimens or alternatively unglazed

tiles fired along with the normal production may be used.

5 PROCEDURE

5.1 Dry the test specimens at 110 ± 5°C until they reach constant mass, that is, when the difference between two successive weighing at intervals of 24 h is less than 0.1 percent. Then allow them to cool in a desiccator at ambient temperature.

5.2 Using Vernier calipers, determine the length to an accuracy of 0.002 times of the length.

5.3 Place a test specimen in the apparatus and note the ambient temperature.

5.4 Initially and throughout the heating procedure, measure the length to an accuracy of 0.01 mm.

5.5 The rate of heating shall be 3°C/min.

6 EXPRESSION OF RESULTS

6.1 The coefficient of linear expansion (α) is expressed to the first decimal place $\times 10^{-6}/^{\circ}\text{C}$ in accordance with the expression:

$$\alpha = \frac{1}{l_0} \times \frac{\Delta l}{\Delta t}$$

where

l_0 = length of test specimens at the ambient temperature;

Δl = increase in the length of the test specimen; and

Δt = rise in temperature.

7 TEST REPORT

The test report shall contain the following:

- a) Brief description of the apparatus;
- b) Description of the tiles; and
- c) Coefficient of linear thermal expansion for both test specimens.

Indian Standard

CERAMIC TILES — METHODS OF TEST, SAMPLING AND BASIS FOR ACCEPTANCE

PART 5 DETERMINATION OF RESISTANCE TO THERMAL SHOCK

(First Revision)

1 SCOPE

This standard (Part 5) covers a method of test for determining the resistance to thermal shock of all ceramic tiles in normal conditions of use.

Depending on the water absorption of the tiles, different procedures (tests with or without immersion) are used unless there is an agreement to the contrary.

2 PRINCIPLE

Determination of resistance to thermal shock of a whole tile by cycling 10 times between the temperature of cold water and a temperature just above that of boiling water. Usually tests are carried out between 15°C and 145°C.

3 APPARATUS

3.1 Low Temperature Bath — Through which cold water flows at $15 \pm 5^\circ\text{C}$. One example is a bath 550 mm long, 350 mm wide and 220 mm deep with water flow rate of 4 litre/min. Any other suitable apparatus may be used.

3.1.1 Testing with Immersion — In the case of all tiles having water absorption not greater than 10 percent the bath is not covered and is of sufficient depth to allow the tiles to be placed vertically and immersed completely.

3.1.2 Testing without Immersion — In the case of glazed tiles having water absorption greater than 10 percent, the bath is covered with a 5 mm thick aluminium plate in such manner that the water, directed towards the surface is in contact with the plate. Covering the aluminium plate is a layer of aluminium grains approximately 5 mm thick with diameters in the range of 0.3 mm to 0.6 mm.

3.2 Oven — Capable of operation at 145°C to 150°C.

4 TEST SPECIMENS

A minimum of five test specimens shall be used.

5 PROCEDURE

5.1 First examine the tiles for visible defects by viewing them with the naked eye (with the aid of spectacles if usually worn) from a distance of 25 cm to 30 cm under

an illumination of approximately 300 lux. All the test specimens shall be free from defects at the commencement of test. The methylene blue solution described in 5.5 may be used to detect pretest defects.

5.2 For Testing with Immersion

In the case of low porosity tiles having water absorption not greater than 10 percent, immerse them vertically in cold water at $15 \pm 5^\circ\text{C}$ so that they are not in contact with each other.

5.3 For Testing without Immersion

In the case of glazed tiles having water absorption greater than 10 percent, place the glazed surface downwards in contact with the aluminium grains over the cold water bath at $15 \pm 5^\circ\text{C}$.

5.4 Temperature Cycling

For both procedures, after 5 min at the low temperature, immediately transfer the test specimens to the oven and keep it at 145°C to 150°C until a uniform temperature is achieved (usually 20 min), and then immediately transfer them back to the low temperature conditions.

Repeat this procedure 10 times.

5.5 Examination

Then examine the test specimens for visible defects by viewing them with the naked eye (with the aid of spectacles if usually worn) from a distance of 25 cm to 30 cm under an illumination of approximately 300 lux. To assist in detecting defects, a suitable stain (such as 1 percent aqueous solution of methylene blue containing a small quantity of wetting agent) may be brushed onto the glazed surfaces of the test specimens. After 1 min, wipe off the stain with a damp cloth.

6 TEST REPORT

The test report shall contain the following:

- a) Description of the tiles;
- b) Water absorption coefficient of the tiles;
- c) Type of test performed (with or without immersion); and
- d) Number of test specimens with visible defects.

*Indian Standard***CERAMIC TILES — METHODS OF TEST,
SAMPLING AND BASIS FOR ACCEPTANCE****PART 6 DETERMINATION OF MODULUS OF RUPTURE
AND BREAKING STRENGTH***(First Revision)***1 SCOPE**

This standard (Part 6) covers a method of test for determining the modulus of rupture and breaking strength of all ceramic tiles.

2 REFERENCE

The standard listed below is necessary adjunct to this standard:

<i>IS No.</i>	<i>Title</i>
3400 (Part 2) : 1995	Methods of test for vulcanized rubbers: Part 2 Hardness (<i>second revision</i>)

3 PRINCIPLE

Determination of modulus of rupture and breaking strength of a whole tile by means of three-point loading, the central point being in contact with the proper surface of the tile.

4 APPARATUS

4.1 **Drying Oven** — Capable of operation at $110 \pm 5^\circ\text{C}$.

4.2 **Recording Gauge** — Accurate to 2 percent.

4.3 **Two Cylindrical Support Rods** — It shall be made of metal and the parts in contact with the test specimen shall be covered with rubber having a hardness of 50 ± 5 IRHD, measured in accordance with IS 3400 (Part 2). One rod shall be slightly pivotable (*see Fig. 1*) and the other shall be slightly rotatable about its own axis (*see Table 1 for relevant dimensions*).

4.4 **Central Cylindrical Rod** — It shall be of the same diameter as the support rods and covered with similar rubber, which transmits the load F . This rod shall also be slightly pivotable (*see Fig. 1*) (*see Table 1 for relevant dimensions*).

5 TEST SPECIMENS

5.1 Whenever possible, whole tiles shall be tested. However, it may be necessary to cut exceptionally large tiles (that is those greater than 300 mm in length) and some non-rectangular shapes in order to fit them in the apparatus. Rectangular test specimens of the largest possible size shall then be cut, having their centres coinciding with the centres of tiles.

5.2 In case of doubt, results obtained using whole tiles

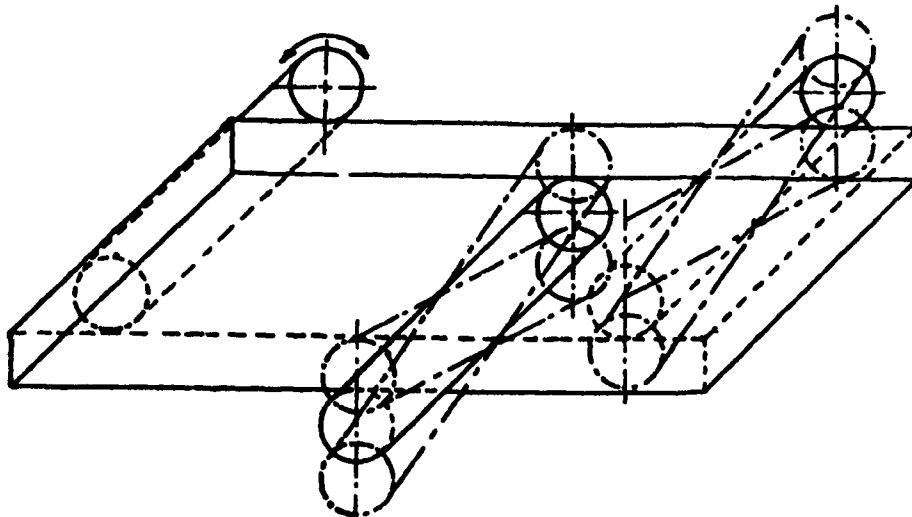


FIG. 1 APPARATUS FOR MEASUREMENT OF MODULUS OF RUPTURE

Table 1 Diameter of Rods, Thickness of Rubber and Length
(Clauses 4.4, 6.2 and 6.6)

Sl No.	Dimension of Tile mm	Diameter of Rod d mm	Thickness of Rubber t mm	Overlap of Tile Beyond the Edge Supports l mm
(1)	(2)	(3)	(4)	(5)
i)	≥ 95	20	5	10
ii)	$< 95 \geq 48$	10	2.5	5
iii)	$< 48 \geq 18$	5	1	2

shall always be preferred to results obtained with cut tiles.

5.3 The minimum number of test specimens for each sample is given in Table 2.

Table 2 Minimum Number of Test Specimens

Sl No.	Dimension of Tile mm	Minimum Number of Test Specimens
(1)	(2)	(3)
i)	≥ 48	7
ii)	$< 48 \geq 18$	10

6 PROCEDURE

6.1 If cut test specimens are to be measured, dry them in the oven at $110 \pm 5^\circ\text{C}$ until constant mass is reached, that is when the difference between two successive weighing at intervals of 24 h is less than 0.1 percent.

6.2 Place a test specimen on two supporting rods, with the glazed or proper surface uppermost so that the test specimen projects by the length l (see Table 1 and Fig. 2) beyond each support rod.

6.3 Position the central rod equidistant between the support rods. Apply the load evenly in such a way as to obtain a rate of increase of stress of $1 \pm 0.2 \text{ N/mm}^2/\text{s}$; the actual rate per second can be calculated by the expression given in 7.

6.4 Note the load to break, F .

6.5 For extruded tiles, place the tiles so that the projecting ribs are at right angles to the support rods. For all other rectangular tiles the greater side is at right angles to the support rods.

6.6 For tiles with relief surfaces, place a second layer of rubber, of the appropriate thickness given in Table 1, on the central rod in contact with the relief surface.

7 EXPRESSION OF RESULT

7.1 Only the results for test specimens that break within a central portion of length equivalent to the

diameter of the central rod shall be used to calculate the average breaking strength and average modulus of rupture.

7.2 A minimum of five acceptable results is necessary to calculate the average value.

7.3 If there are fewer than five acceptable results, a second sample shall be tested consisting the double the number of tiles.

7.4 A minimum of ten acceptable results is then required to calculate the average value.

7.5 The breaking strength (S), expressed in newtons, is calculated by means of the expression:

$$S = FL/b$$

where

F = load required to break the tile, in N;

L = span of the support rods, in mm (see Fig. 2);
and

b = width of the tile, in mm.

7.6 The modulus of rupture (δ), expressed in newtons/ mm^2 , is calculated by means of the expressions.

$$\delta = 3FL/2bh^2$$

where

F = load required to break the tile, in N;

L = span of the support rods, in mm (see Fig. 2);
 b = width of the tile, in mm; and

h = minimum thickness of the test specimen measured after the test along the broken edge, in mm.

NOTE — The calculation of the modulus of rupture is based on a rectangular cross-section. In the case of tiles of variable thickness along the broken edge, approximate results only are produced. The shallower the relief, the more exact is it possible to make the approximations.

7.7 Note all results for breaking strength and modulus of rupture.

7.8 Calculate the average breaking strength and average modulus of rupture of the samples as the average of the acceptable results.

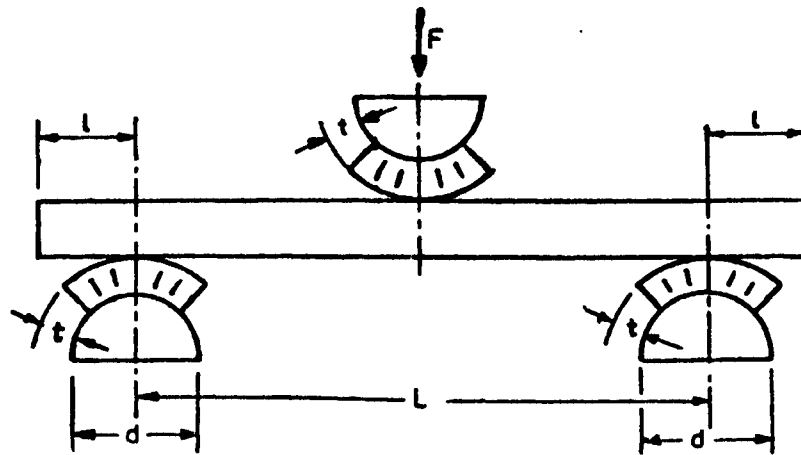


FIG. 2 SECTION ACROSS MODULUS OF RUPTURE APPARATUS

8 TEST REPORT

The test report shall contain the following:

- a) Description of the tile;
- b) Number of test specimens;
- c) Values of d , t , l , L and F ;
- d) Modulus of rupture and breaking strength of each test specimen; and
- e) Average modulus of rupture and breaking strength.

*Indian Standard***CERAMIC TILES — METHODS OF TEST,
SAMPLING AND BASIS FOR ACCEPTANCE****PART 7 DETERMINATION OF CHEMICAL RESISTANCE —
UNGLAZED TILES***(First Revision)***1 SCOPE**

This standard (Part 7) covers a method of test for determining the chemical resistance of the proper surface of all unglazed ceramic tiles.

2 REFERENCE

The standard listed below is necessary adjunct to this standard:

<i>IS No.</i>	<i>Title</i>
2303 : 1994	Method of grading glass for alkalinity (first revision)

3 PRINCIPLE

The test specimens are partially immersed in the test solution and attack is determined visually after 28 days.

4 AQUEOUS TEST SOLUTIONS**4.1 Household Chemicals**

- a) *Ammonium Chloride Solution*, 100 g/l.
- b) Standard cleaning agent solution prepared from:
 - 1) Anhydrous sodium carbonate 33 percent (*m/m*)
 - 2) Sodium perborate 7 percent (*m/m*)
 - 3) Sodium silicate solution of density 1.33 g/cm³ 7 percent (*m/m*)
 - 4) Commercial sodium oleate soap flakes 30 percent (*m/m*)
 - 5) Distilled water or de-ionized water 23 percent (*m/m*)

NOTE — The soap can be prepared from concentrated sodium hydroxide solution and oleic acid in the proportions of 2.6 g to 18.5 g respectively.

- c) 100 g of this standard cleaning agent contain 70 g of dry substance. Use in a concentration of 10 g dry substance per litre. The test solution shall be prepared immediately before use.

4.2 Swimming Pool Salts

- a) Sodium hypochlorite solution 20 mg/l, prepared from technical grade hypochlorite with about 13 percent active chlorine, and
- b) Copper sulphate solution, 20 mg/l.

4.3 Acids

- a) Sulphuric acid solution, 70 percent (*v/v*) prepared from concentrated sulphuric acid ($d \approx 1.84$). Cautiously add the sulphuric acid to water, cooling the solution and keeping it well mixed during addition.
- b) Lactic acid solution 5 percent (*v/v*) (available in this concentration).

4.4 Alkali

Potassium hydroxide solution 200 g/l.

5 APPARATUS

5.1 Vessel — With a lid, made of borosilicate glass 3.3 conforming to Type 1 when graded according to IS 2303 or any other suitable material.

5.2 Drying Oven — Capable of operation at $110 \pm 5^\circ\text{C}$.

5.3 Chamois Leather

5.4 Balance — Accurate to 0.05 g

6 TEST SPECIMENS**6.1 Number of Test Specimens**

Five test specimens shall be used with each test solution.

6.2 Size of Test Specimens

A square test specimen 50 mm \times 50 mm shall be cut from each tile under test in such a manner that one side of each test specimen is not a cut side.

6.3 Preparation of Test Specimens

Thoroughly clean the proper surface with a suitable solvent, for example, methanol. Test specimens with surface defects shall be excluded from the test.

7 PROCEDURE

7.1 Dry the test specimens at $110 \pm 5^\circ\text{C}$ until they reach to constant mass when the difference between the successive weighing is less than 0.1 g, and cool to room temperature.

7.2 Immerse the test specimens vertically to a depth of 25 mm in the test solution (which may be any of those listed in 4) in the test vessel. The non-cut side of each test specimen shall be fully immersed. Cover with the lid and maintain the test assembly for 28 days at $27 \pm 2^\circ\text{C}$.

7.3 After 28 days subject the test specimens to running water for 7 days and then boil them for $\frac{1}{2}$ h while completely immersed in water. Remove the test specimens from the water and dab with wet but wrung out chamois leather.

7.4 Examine the test specimen with naked eye, with

spectacles usually worn, for changes on the proper surface and the non-cut edge. Secondly examine the parts of the cut edges that were immersed.

8 TEST REPORT

The test report shall contain the following:

- a) Description of the tile;
- b) Test solution(s) used;
- c) Number of test specimens;
- d) Number of test specimens damaged by each test solutions;
- e) Visual changes on the proper surface as a result of the test specified in 7;
- f) Visual changes on the non-cut edges as a result of the test specified in 7; and
- g) Visual changes on the cut-edges as a result of the test specified in 7.

*Indian Standard***CERAMIC TILES — METHODS OF TEST,
SAMPLING AND BASIS FOR ACCEPTANCE****PART 8 DETERMINATION OF CHEMICAL RESISTANCE —
GLAZED TILES***(First Revision)***1 SCOPE**

1.1 This standard (Part 8) covers a method of test for determining the chemical resistance of the proper surface of all glazed ceramic tiles at room temperature.

1.2 The method is applicable to all glazed ceramic tiles except that the pencil test is only applied to glazes from which pencil marks can be removed by means of a dry cloth.

1.3 Where the pencil test is not applicable, the glazes can be classified by the change in appearance resulting from chemical action.

1.4 The stain test is not applicable tiles described as part glazed.

2 REFERENCE

The standard listed below is necessary adjunct to this standard:

<i>IS No.</i>	<i>Title</i>
2303 : 1994	Method of grading glass for alkalinity (<i>first revision</i>)

3 PRINCIPLE

3.1 For testing the resistance to staining, the test solutions are allowed to drop on and dry and then the test surfaces are inspected for visual changes.

3.2 For testing the resistance to household chemicals, swimming pool salts and citric acid, part of the glazed surface is subjected to the action of the test solution for 6 h and then inspected for visual changes.

3.3 For testing the resistance to hydrochloric acid and potassium hydroxide the procedure is similar except that the period of test is 7 days.

4 AQUEOUS TEST SOLUTIONS**4.1 Stains**

- a) *Methylene Blue*, 10 g/l, and
- b) *Potassium Permanganate Solution*, 10 g/l.

4.2 Household Chemicals

- a) *Ammonium Chloride Solution*, 100 g/l;

- b) Standard cleaning agent solution, prepared from:

- 1) Anhydrous sodium carbonate 33 percent (*m/m*)
- 2) Sodium perborate 7 percent (*m/m*)
- 3) Sodium silicate solution of density 1.33 g/cm³ 7 percent (*m/m*)
- 4) Commercial sodium oleate soap flakes 30 percent (*m/m*)
- 5) Distilled water or de-ionized water 23 percent (*m/m*)

- c) 100 g of this standard cleaning agent contain 70 g of dry substance. Use in a concentration of 10 g dry substance per litre. The test solution shall be prepared immediately before use.

NOTE — The soap can be prepared from concentrated sodium hydroxide solution and oleic acid in the proportion of 2.6 g to 18.5 g respectively.

4.3 Swimming Pool Salts

- a) Sodium hypochlorite solution 20 mg/l, prepared from technical grade hypochlorite with about 13 percent active chlorine.
- b) Copper sulphate solution, 20 mg/l.

4.4 Acids

- a) *Hydrochloric Acid Solution*, 3 percent (*v/v*) prepared from concentrated sulphuric acid ($d \approx 1.19$); and
- b) *Citric Acid Solution*, 100 g/l.

4.5 Alkali

Potassium hydroxide solution 200 g/l.

5 APPARATUS

5.1 **Vessel** — A cylinder of borosilicate glass conforming to Type 1 when graded according to IS 2303 or any other suitable material having a lid or an opening for filling. The bottom edge of the cylinder shall be ground flat and perpendicular to the vertical axis of the cylinder. Variations from the experimental

arrangement are permitted in order to accommodate different sizes.

5.2 Sealing Material

5.3 Cloth — White cotton or flax.

5.4 Pencil — HB hardness or equivalent.

5.5 Electric Lamp — 40 W, inside white (for example, siliconized).

6 TEST SPECIMENS

6.1 Size of Test Specimens

For testing according to 3.2, undamaged test specimens shall be used and they shall consist of either whole tile or parts of tiles.

6.2 Number of Test Specimens

Five test specimens shall be used with each test solution.

6.3 Preparation of Test Specimens

Thoroughly clean the proper surface with a suitable solvent, for example, methanol. Test specimens with surface defects shall be excluded from the test.

7 PROCEDURE

7.1 Application of Test Solution

7.1.1 Testing in Accordance with 3.1

Allow 3 or 4 drops of each of the test solutions specified in 4.1 to fall on a fresh part of the test specimen. Place an approximately 30 mm diameter convex watch glass on the applied drop in order to spread it to an approximately circular area. Allow to remain for 24 h and then rinse the surface with running water and wipe with a damp cloth. If a stain remains, thoroughly clean with a solution of the standard cleaning agent.

7.1.2 Testing in Accordance with 3.2

7.1.2.1 Apply a uniform layer of the sealing material 3 mm thick, to the rim of the cylinder. Turn the cylinder upside down onto a fresh part of the glazed surface as shown in Fig. 1 and seal around the rim.

7.1.2.2 Pour the test solution through the inlet to a height of 20 ± 1 mm maintain the test assembly at a temperature of $27 \pm 2^\circ\text{C}$.

7.1.2.3 For testing resistance to household chemicals, swimming pool salts and citric acid, maintain the test solution in contact with the test specimens for 6 h. Remove the cylinder and clean the glazed surface with a grease solvent.

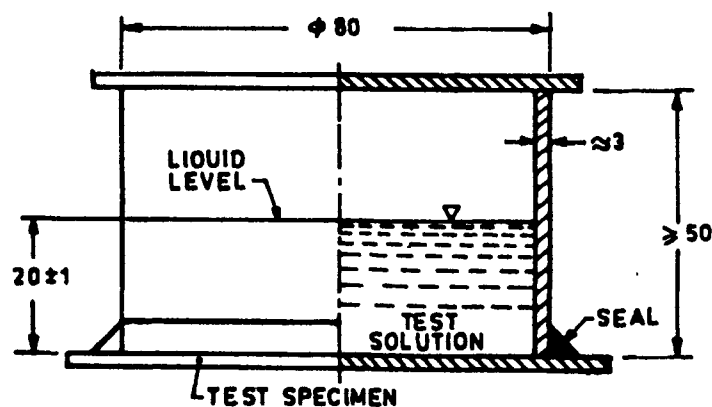
7.1.2.4 For testing resistance to hydrochloric acid and potassium hydroxide, maintain the test solution in contact with the test specimens for 7 days.

7.1.2.5 Shake the test assembly gently once in a day and ensure that the level of the test solution does not change. Replace the test solution after 4 days. After 3 more days, remove the cylinder and clean the glazed surface with a grease solvent.

7.2 Determination After Procedure in Accordance with 7.1.2

7.2.1 General

The surface that has been tested has to completely dry before assessment can commence. In order to assess whether the pencil test is applicable, draw several lines with an HB pencil on the untreated parts of the glazed surfaces and attempt to remove the marks with a dry cloth. If the pencil marks cannot be removed, the test specimens can only be assessed visually and the classification scheme of Fig. 2 is not applicable. For all other test specimens, the assessment shall be carried out according to 7.2.2 to 7.2.4.



All dimensions in millimetres.

FIG. 1 EXAMPLE OF AN EXPERIMENTAL ARRANGEMENT FOR THE TEST DESCRIBED IN 3.2

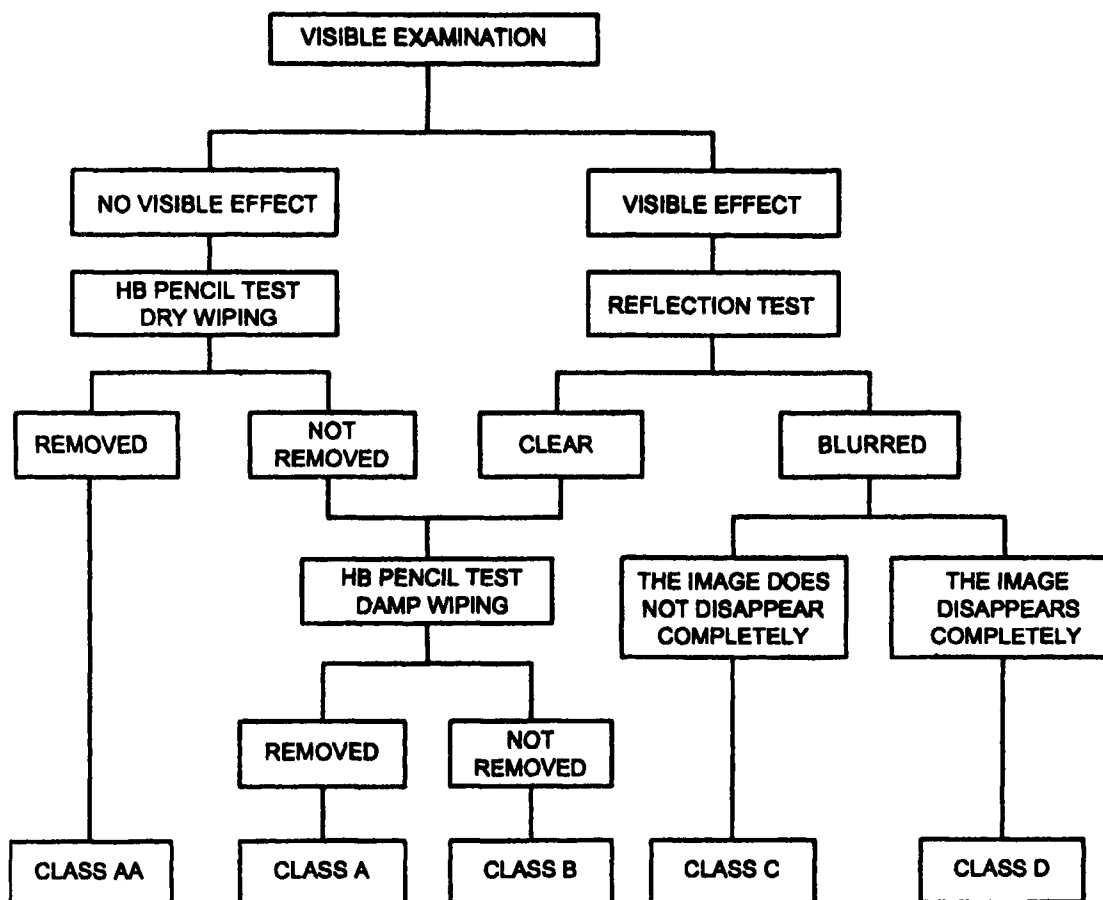


FIG. 2 CLASSIFICATION SCHEME FOR TESTS WITH HOUSEHOLD CHEMICALS, SWIMMING POOL SALTS, ACIDS AND ALKALIS

7.2.2 Initial Visual Examination

7.2.2.1 Examine the surface that has been tested from all angles from a standard distance of 250 mm with naked eye, with the aid of spectacles if usually worn, for any difference in appearance from an untreated surface, for example, for change in reflection or the development of brilliance.

7.2.2.2 The illumination is permitted to be artificial or daylight, but direct sunlight shall be avoided.

7.2.2.3 After examination, if there is no visible effect, perform the pencil test (see 7.2.3). If there is a visible effect, perform the reflection test (see 7.2.4).

7.2.3 Pencil Test

7.2.3.1 Draw several lines with an HB pencil both on the surface under test and on the untreated surface.

7.2.3.2 Attempt to remove the pencil lines by means of a soft dry cloth. If removed, the surface corresponds to Class AA. If not removed, attempt to remove the pencil lines by means of a soft damp cloth which has been dampened by dipping in distilled or de-ionized

water and then wringing out. If removed surface corresponds to Class A, if not removed to Class B.

7.2.4 Reflection Test

7.2.4.1 Hold the tile in such a manner that the image of the lamp is reflected on the untreated surface. The angle of incidence of the light upon the surface shall be approximately 45° and the distance between the tile and the light source shall be 350 ± 100 mm.

7.2.4.2 The criteria of judgment shall be the sharpness of the reflection and not the brightness of the surface. Position the tile so that the image fall simultaneously on both treated and untreated part and determine whether it is any less clear in the treated part.

7.2.4.3 This test cannot be applied to certain glazes, in particular, which are dull.

7.2.4.4 If the reflection is clear, perform the pencil test with damp wiping. If the lines are removed the surface corresponds to Class A; if not removed to Class B.

7.2.4.5 If the reflection is blurred, but does not

disappear completely, the classification is C and if the image disappears completely, the classification is D.

8 CLASSIFICATION OF RESULTS

8.1 Classification by Staining Test

8.1.1 In consequence of the procedure with stain solution, which has been performed in accordance with 7.1.1, glazes are divided into three classes given in Table 1. Record the result for each test specimen with each stain solution.

Table 1 Classification by Staining Test

Test Solution (1)	Observation (2)	Class (3)
Methylene blue	Stain removed by water	1
	Stain removed by cleaning agent	2
Potassium permanganate	Stain not removed	3

8.2 Classification by Testing with Household Chemicals, Swimming Pool Salts, Acids and Alkalis

8.2.1 Assessment in Accordance with Fig. 2

In consequence of the determinations with household chemicals, swimming pool salts, acids and alkalis performed in accordance with 7.1.2 glazes are divided into several classes as given in the scheme shown in Fig 2. Record the result for each test specimen with each test solution

8.2.1.1 Classes of resistance

AA = resistant,

- A = less resistant than AA but more resistant than B,
- B = less resistant than A but more resistant than C,
- C = less resistant than B, and
- D = not resistant.

8.2.2 Assessment not in Accordance with Fig. 2

In consequence of the determinations with household chemicals, swimming pool salts, acids and alkalis performed in accordance with 7.1.2 glazes are divided into several classes as assessed visually. These are glazes for which pencil test and/or reflection test are not applicable. Record the result for each test specimen with each test solution.

8.2.2.1 Classes of resistance

- AA = no visible effect,
- A = slight change in appearance,
- B = definite change in appearance,
- C = partial loss of the original surface, and
- D = total loss of the original surface.

9 TEST REPORT

The test report shall contain the following:

- a) Description of the tile;
- b) Test solutions used;
- c) Visual changes on the proper surface as a result of the test specified in 7; and
- d) Classification for each test solution and for each test specimen according to 8.

Indian Standard

**CERAMIC TILES — METHODS OF TEST,
SAMPLING AND BASIS FOR ACCEPTANCE**

PART 9 DETERMINATION OF CRAZING RESISTANCE — GLAZED TILES

(First Revision)

1 SCOPE

This standard (Part 9) covers a method of test for determining the crazing resistance of all glazed tiles except when the crazing is an inherent feature of the product.

2 TERMINOLOGY

2.1 For the purpose of this standard, the following definition shall apply.

2.2 **Craze** — A craze is a crack, showing as a fine hairline, limited to the glazed surface of a tile (see Fig. 1).

3 PRINCIPLE

The resistance to the formation of crazes is determined by subjecting whole tiles to steam at high pressure in an auto clave and then examining the tiles for crazes after applying a stain to the glazed faces.

4 APPARATUS

4.1 A steam autoclave of sufficient internal volume to accommodate five tiles under test with adequate separation. Ideally, the steam is fed from an external source in order to maintain a pressure of 750 ± 20 kPa with a steam temperature of $168 \pm 1^\circ\text{C}$ for 2 h. Then the pressure is allowed to fall rapidly as possible to atmospheric temperature and the test specimens are allowed to cool to room temperature.

4.2 Alternatively, a directly heated autoclave may be used.

5 TEST SPECIMENS

5.1 At least five whole tiles are tested.

5.2 Exceptionally large tiles may be cut into pieces for enclosure in the steam autoclave, but all the pieces shall be tested. The cut pieces should be as large as possible.

6 PROCEDURE

6.1 First, examine the tiles for visible defects by viewing them with the naked eye (with the aid of spectacles if usually worn). All test specimens shall be free from crazes at the commencement of the test.

6.2 Place the test specimens in the autoclave in such way that there is air space between them. Raise the pressure of the autoclave gradually for a period of 1 h until it reaches 750 ± 20 kPa. This pressure is to be maintained for 2 h. Then turn off the steam source or the heat supply in the case of directly heated autoclaves, allow the pressure to fall as rapidly as possible to atmospheric and cool the test specimens in the autoclave for 30 min. Remove test specimens to the laboratory atmosphere, place them singly on a flat surface and allow them to cool for a further period of 30 min.

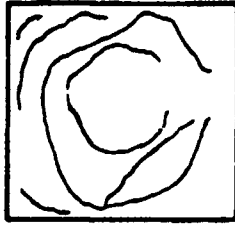
6.3 Brush a suitable stain, such as 1 percent aqueous solution of methylene blue containing a small quantity of wetting agent, on to the glazed surface of the test specimens. After 1 min wipe off the stain with a damp cloth.

6.4 Examine the test specimens for crazes taking care to avoid confusing crazes with scratches and ignoring cracks.

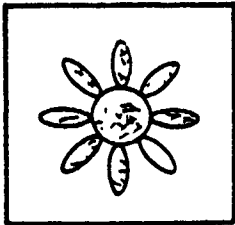
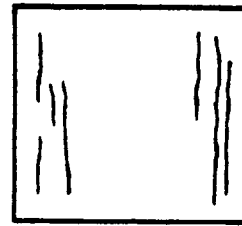
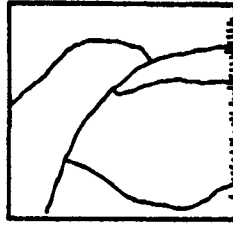
7 TEST REPORT

The test report shall contain the following:

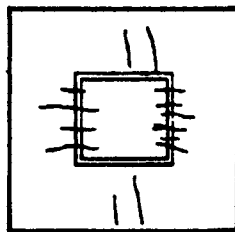
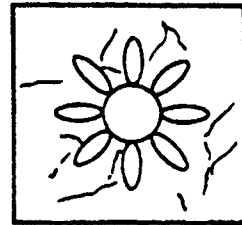
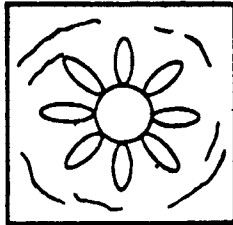
- a) Description of the tile;
- b) Number of test specimens;
- c) Number of test specimens showing crazing; and
- d) Description of the crazing (written text, drawing or photograph).



PLAIN TILES



DECORATED TILES



RELIEF SURFACED TILES

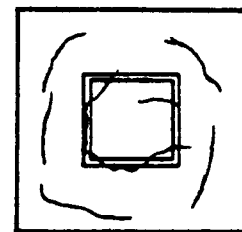
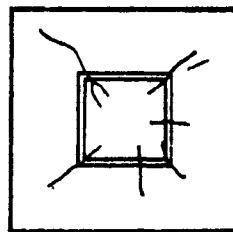


FIG. 1 EXAMPLES OF CRAZES

Indian Standard

CERAMIC TILES — METHODS OF TEST, SAMPLING AND BASIS FOR ACCEPTANCE

PART 10 DETERMINATION OF FROST RESISTANCE

(First Revision)

1 SCOPE

This standard (Part 10) covers a method of test for evaluating the frost resistance of all ceramic tiles intended for use in conditions of frost in the presence of water.

2 PRINCIPLE

After impregnation with water tiles are cycled between +15° and -15°C. All sides of tiles are exposed to freezing during 50 freeze-thaw cycles.

3 APPARATUS

3.1 **Drying Oven**, capable of operation at $110 \pm 5^\circ\text{C}$.

3.2 **Balance**, weighing to 0.1 percent of the mass of a test specimen.

3.3 **Container**, for impregnation by capillarity or immersion with stable horizontal supports.

3.4 **Apparatus for impregnation with water after evacuation** by means of a vacuum pump capable of lowering than air pressure by 40 ± 2.6 kPa in a tank containing tiles.

3.5 A freezer capable of freezing at least ten tiles having a minimum total area of 0.25 m^2 supported in such a manner that the tiles shall be separated. The freezer shall be capable of reducing the temperature to $-15 \pm 3^\circ\text{C}$ in 2 h, if the freezer is automated it shall comply with the freeze-thaw cycling conditions. The temperature shall be as uniform as possible in the freezer and it shall have air circulation (measured in the empty freezer) with a maximum air velocity of 4 m/s.

3.6 Chamois Leather

3.7 Demineralized water, if water hardness less than 400 mg/l $\text{CaCO}_3 + \text{MgCO}_3$ (or equivalent hard water salts) at 15° to 25°C is not available.

4 TEST SPECIMENS

4.1 Sample

A minimum area of 0.25 m^2 and not less than 10 whole tiles shall be used. The tiles shall be free from dust.

NOTE — If tiles with defects such as cracks, crazing, holes, nipped edges and nipped corners have to be tested then the defects shall be marked with a permanent stain prior to the test and these defects shall be examined after testing.

4.2 Preparation

Dry the tiles in the oven at $110 \pm 5^\circ\text{C}$ until constant mass is reached, that is, when the difference between two successive weighing at intervals of 24 h is less than 0.1 percent. Record the dry mass of each tile (M_1).

5 IMPREGNATION WITH WATER

5.1 Progressive Water Impregnation by Capillarity Whatever the Water Absorption

5.1.1 Place the tiles vertically in the container with no contact between them and no contact with the container so that one lone side shall be standing on the supports.

5.1.2 Add water to the level of one-fifth of the height of the tiles. Add additional quantities of water at subsequent 24 h intervals so that a further one-fifth of the height shall be immersed each 24 h with the fifth and final addition of water add sufficient to immerse the tiles under a 50 mm head of water. After the fifth day allow the tiles to remain under water for a further period of 2 days so that they shall be fully immersed for 3 days.

5.1.3 Prepare chamois leather by wetting and wringing out by hand. Place the chamois leather on a flat surface and lightly dry each side of each tile in turn. Dab relief surface with chamois leather.

5.1.4 Weigh each tile immediately after this procedure.

5.1.5 Record the wet mass of each tile (M_2).

5.2 Water Impregnation at Atmospheric Pressure for Tiles with Water Absorption ≤ 6 Percent

5.2.1 Place the tiles vertically in the container with no contact between them and no contact with the container so that one lone side shall be standing on the supports. Add water so as to completely immerse the tiles and allow to stand for 24 h.

5.2.2 Lightly dry the surface of each tile with damp chamois leather using procedure given in 5.1. Weigh

each tile. Repeat this procedure of natural immersion for further periods of 24 h each until the change in mass between two successive weighing shall be less than 0.1 percent of total mass. There shall be a minimum time of immersion of 3 days.

5.2.3 Record the wet mass of each tile (M_2).

5.3 Water Impregnation by Evacuation for Tiles with Water Absorption > 6 Percent

5.3.1 Place the tiles vertically in the dry vacuum tank with no contact between them and no contact with the vacuum tank. Connect to the vacuum pump and evacuate to a pressure of 40 ± 2.6 kPa below atmospheric pressure and maintain the pressure for 30 min. bring the water into the tank containing the tiles whilst maintaining this pressure and cover the tiles by at least 50 mm head of water. This operation shall take 30 min maintain the evacuation at the same pressure for a further 30 min and then restore atmospheric pressure. Leave the tiles under water for 1 h before removing them.

5.3.2 Lightly dry the surface of each tile with damp chamois leather using the procedure given in 5.1.

5.3.3 Record the wet mass of each tile.

5.4 Calculation of Water Content

The water content expressed as a percentage (by mass) is determined from:

$$W_{c_1} = \frac{(M_2 - M_1)}{M_1} \times 100$$

where

W_{c_1} = water content by mass (percent),

M_1 = dry mass of each tile, and

M_2 = wet mass of each tile.

6 PROCEDURE

6.1 Select the appropriate impregnation method. The reference method to be used for arbitration shall be the method of progressive water impregnation by capillarity.

6.2 Select one of the thickest tiles that are under test. It shall be one considered to have repressive properties of that test sample. Drill a 3 mm diameter hole from the centre of one edge to a maximum distance of 40 mm from the edge of the tile. Insert thermocouple or other suitable measuring device and seal the hole with a tiny piece of thermally insulating material (for example, extended polystyrene). If it is not possible to drill a hole in this way, place a thermocouple on the center of each face of a tile and adhere a second tile over this.

6.3 Place all the tiles under test in the freezer in such way that there is air space between each one and air flow over all surfaces. Place the tile with thermocouple in the middle of the test samples. The temperature of the thermocouple defines the temperature of the entire tile under test. Only in the case of repeated tests with similar test specimens can this be omitted and then occasional check shall be made with a thermocouple in a tile. When there is no temperature reference tile the air temperature shall be measured. All temperature measurements shall be accurate to $\pm 0.5^\circ\text{C}$. Ideally testing shall then be proceeded by automated freeze-thaw cycling. Whether automated or not the temperature time relationship shall be within the range defined in Fig. 1.

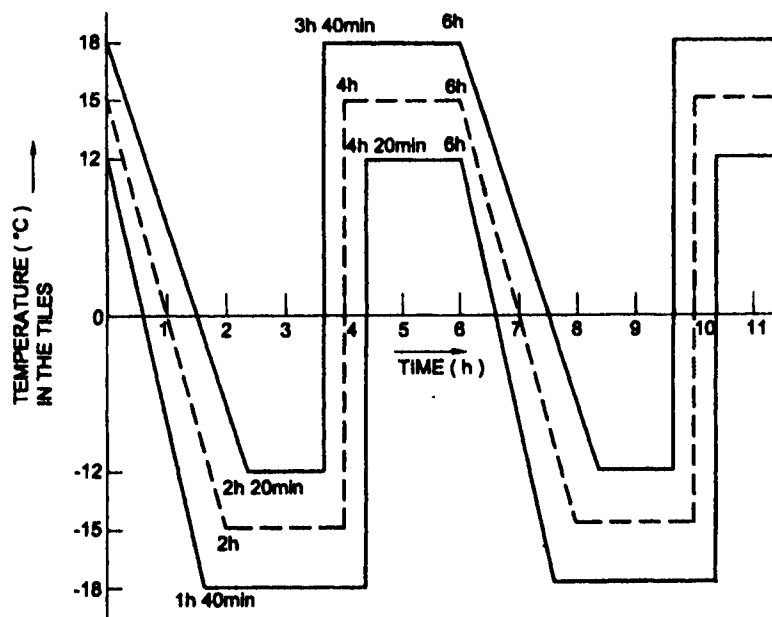


FIG. 1 SCHEMATIC REPRESENTATION OF TEMPERATURE CURVE

The freezer can be controlled by means of the air temperature but Fig. 1 refers to the temperature in the tiles under test. The ideal freeze-thaw cycle in the tile is indicated by dotted line and actual freeze-thaw cycle shall be within the zone delineated by the two other line. The cycle shall be completed after 6 h.

6.4 Immerse the tiles in water at $+15 \pm 3^\circ\text{C}$ drain the water before reaching 5°C . The temperature shall be reduced to $-15 \pm 3^\circ\text{C}$ in $2\text{h} \pm 20\text{ min}$ from commencement of the cycling. Adequate provision shall be made to prevent evaporation of water during cooling if the water is drained at a temperature above 5°C keep the tiles at $15 \pm 3^\circ\text{C}$ for $2\text{h} \pm 20\text{ min}$ and then introduce water at $+15 \pm 3^\circ\text{C}$ and maintain this for $2\text{h} \pm 20\text{ min}$ repeat the cycling procedure 50 times, as shown in Fig. 2 weigh the tiles after test (M_3) and then dry them to constant mass (M_4). The final water content expressed as a percentage (by mass) is determined from:

$$W_{c_2} = \frac{(M_3 - M_4)}{M_4} \times 100$$

where

- W_{c_2} = final water content by mass (percent),
- M_3 = wet mass of each tile after the test, and
- M_4 = dry mass of each tile after the test.

6.5 Examine the glazed or proper surfaces and the edges of the tiles by the naked eye, with the aid of spectacle if usually worn, after 50 cycles. They may be examined at the intermediate stages to expedite the reporting if there is a reason to believe that they might sustain damage relatively early in the test. Record all damage that is observed on the glazed or proper surfaces and the edges of the tiles.

7 TEST REPORT

The test report shall contain the following:

- a) Identification of the tile;
- b) Number of tiles in the test sample;
- c) Method used to impregnate the tiles with water;
- d) Water content obtained before the freeze-thaw test;
- e) Water content obtained after the freeze-thaw test;
- f) Description of defects before the test and all damage on the glazed or proper surfaces and the edges of the tiles after the freeze-thaw test; and
- g) Number of damaged tiles after 50 cycles.

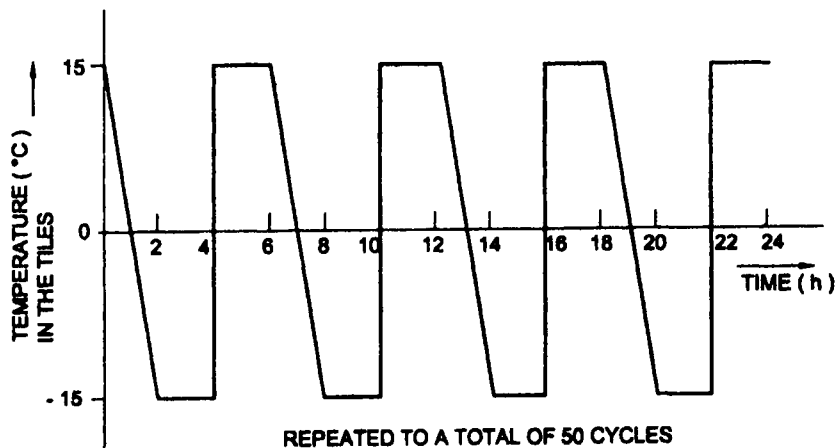


FIG. 2 SCHEMATIC DIAGRAM OF THE FREEZE-THAW CYCLES

Indian Standard

**CERAMIC TILES — METHODS OF TEST,
SAMPLING AND BASIS FOR ACCEPTANCE**

**PART 11 DETERMINATION OF RESISTANCE OF SURFACE ABRASION —
GLAZED TILES**

(First Revision)

1 SCOPE

This standard (Part 11) covers methods of test for determining the resistance to surface abrasion of all glazed ceramic tiles used for floor covering.

2 REFERENCE

The standard listed below is necessary adjunct to this standard:

<i>IS No.</i>	<i>Title</i>
11643 : 1985	Specification for silicon carbide for bonded abrasive products

3 PRINCIPLE

Determination of the abrasion resistance of the glaze of tiles by rotation of an abrasive load on the surface and assessment of the wear by means of visual comparison of abraded test specimens and non-abraded tiles.

4 ABRASIVE LOADS

The total load on each test specimen consists of:

- a) 70.0 g of 5 mm diameter steel balls,
- b) 52.5 g of 3 mm diameter steel balls,
- c) 43.75 g of 2 mm diameter steel balls,
- d) 8.75 g of mm diameter steel balls,
- e) 3.0 g white fused aluminum oxide conforming to the grain size requirement of Grit No. 80 of Table I of IS 11643, and
- f) 20 ml of de-ionized or distilled water.

5 APPARATUS

5.1 Abrasion Apparatus — The abrasion apparatus consists of a steel case with an inbuilt electrical drive connected to a horizontal supporting plate of diameter 580 mm with positions for test specimens of dimensions at least 100 mm × 100 mm (*see* Fig. 1). The distance between the centre of the supporting plate and the centre of each position shall be 195 mm. There shall be equal distances between each adjacent position. The supporting plate rotates at 300

revolutions per minute with an eccentricity (*e*) of 22.5 mm so that every part of each test specimen describes a circular motion of diameter 45 mm. The test specimens are held down with the aid of metal holders which are provided with rubber seals (*see* Fig. 2). The internal diameter of the holders is 83 mm, thus providing a test area of about 54 cm². The thickness of the rubber is 9 mm and the height of the space under the holder is 25.5 mm.

5.1.1 The apparatus switches off automatically after completion of a preset number of revolutions.

5.1.2 The supporting plate with holders and test specimens shall be covered during operation.

5.1.3 A suitable apparatus of another description may be used, provided that the results comply with the results from the apparatus described above.

5.2 Apparatus for Visual Assessment — The apparatus consists of a viewing box equipped with fluorescent lighting of colour temperature 6 000 K to 6 500 K placed vertically above the surface to be observed providing 300 lux illuminance. The dimensions of the box shall be 61 cm × 61 cm × 61 cm and the inner faces shall be painted a neutral grey. Tight source is screened to avoid direct viewing.

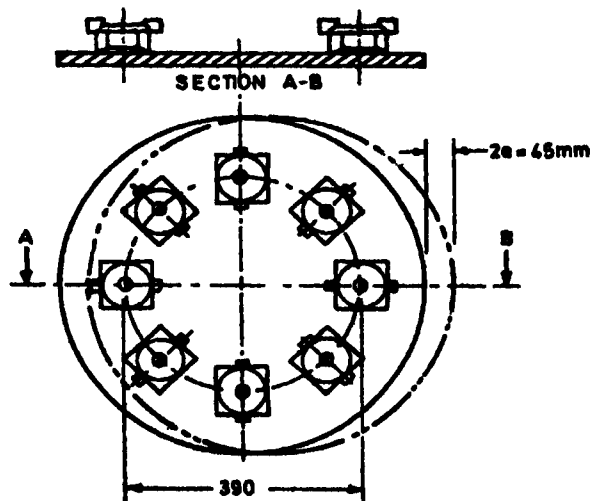
5.3 Drying Oven, capable of operation at 110 ± 5°C.

5.4 Balance, if mass loss is required.

6 TEST SPECIMENS**6.1 Types of Test Specimens**

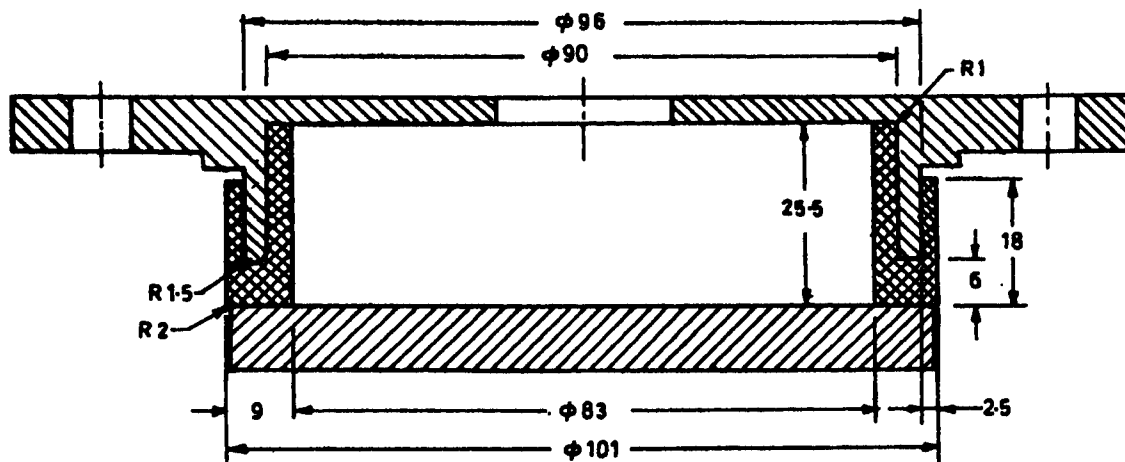
6.1.1 Test specimens shall be representative of the sample; where tiles have different colour or decorative effects in parts of the surface, care should be taken to include all distinctive parts.

6.1.2 The usual facial dimensions of test specimens are 100 mm × 100 mm. Test specimens with smaller facial dimensions shall be fastened close together on a suitable supporting material. Edge effects at the narrow joints shall be ignored.



All dimensions in millimetres.

FIG. 1 APPARATUS WITH POSITIONS FOR EIGHT SPECIMEN HOLDERS



All dimensions in millimetres.

FIG. 2 SPECIMEN HOLDER

6.2 Number of Test Specimens

6.2.1 Eleven test specimens are required. In addition, eight test specimens are required for the visual assessment.

6.2.2 The procedure requires one test specimen for each stage of abrasion and subsequently, an additional three test specimens to check the result at the visual failure point.

6.3 Preparation

The glazed surface of the test specimen shall be clean and dry.

7 PROCEDURE

7.1 Calibration of the abrasion apparatus is only

necessary occasionally or when there is doubt regarding the validity of the results. One possible calibration method is given in the Annex A.

7.2 Clamp a metal holder on to the glazed surface of each test specimen on the abrasion apparatus. Introduce the abrasive load into the holder through a hole in its upper surface. The hole may then be sealed to prevent loss from the abrasive load. The number of revolutions of the preset counter required for each abrasion stage of the test is 100, 150, 600, 750, 1 500, 2 100, 6 000 and 12 000. Remove one test specimen after each abrasion stage and continue the test until failure is observed.

7.3 After abrasion, rinse the test specimens under running water and dry in the oven at $110 \pm 5^\circ\text{C}$. If the

test specimens are stained with iron oxide, completely remove the stain with 10 percent (v/v) hydrochloric acid. Immediately rinse under the running water and dry.

7.4 For the visual comparison, surround an abraded test specimen by unabraded tiles of exactly the same type in an apparatus for visual assessment under an illumination of 300 lux. View with the naked eye (or with the aid of spectacles, if usually worn) from a distance of 2 m and a height of 1.65 m. Note the number of revolutions at which any change in the area that has been subjected to abrasion can be readily distinguished. The consensus of at least three observers is required.

7.5 The result is checked by retesting at the abrasion stage when failure is observed and at the next higher and lower abrasion stages. If the result is not the same, the lower of the two abrasion stages shall be used to decide the classification.

7.6 Then test the abraded area of the tile which has passed 12 000 revolutions stage for stain resistance in accordance with IS 13630 (Part 8).

7.7 After use, the steel balls should be cleaned with water followed by methylated spirits and then thoroughly dried to prevent rusting. Before each test, screen the steel balls in the abrasive load into specified size categories and replace any mass in each size categories.

7.8 If there is an agreement to determine the mass lost from a surface during abrasion testing, this shall be obtained by measuring the dry mass of three test specimens before the test and after 6 000 revolutions. Upon agreement subsequently test abraded tiles which have passed 1 500, 2 100 and 6 000 revolutions stages for stain resistance in accordance with IS 13630 (Part 8) at the abrasion stage at which visual failure occurred. Other relevant properties may be determined by agreement during the execution of the test procedures

for instance change of colour or gloss. The additional information, which is obtained by agreement, shall not be used to classify tiles.

8 CLASSIFICATION OF RESULTS

The test specimens are classified according to Table 1. In order to be classified as Class 5, the tile must also pass the test specified in IS 13630 (Part 8) test for resistance to stains on the abraded area. If there is no visual failure after 12 000 revolutions but if stains cannot be removed by any standard procedure the tile shall be Class 4.

Table 1 Classification of Glazed Ceramic Tiles

Sl No.	Abrasion Stage; Failure Visible at Revolutions	Class
(1)	(2)	(3)
i)	100	0
ii)	150	1
iii)	600	2
iv)	750, 1 500	3
v)	2 100, 6 000, 12 000	4
vi)	> 12 000 ¹⁾	5

¹⁾ Must pass the test specified in IS 13630 (Part 8).

9 TEST REPORT

The test report shall contain the following:

- Description of the tiles;
- Preparation of test specimens;
- Test method;
- Classification according to 8;
- Abrasion stage at which visual failure occurred; and
- Mass loss, colour change, gloss change of other properties measured by agreement.

ANNEX A

(Clause 7.1)

CALIBRATION OF THE ABRASION APPARATUS USING FLOAT GLASS

A-1 REFERENCE MATERIAL

The reference material shall be float glass with a minimum thickness of 6 mm.

A-2 IDENTIFICATION OF THE FLOAT BATH SURFACE OF THE GLASS

As the calibration test is carried out on the float bath

side, this has first to be identified. One of the following methods can be used.

A-2.1 Chemical Method

A-2.1.1 Reagents

A-2.1.1.1 *Etching solutions* — Thoroughly mix 10 volumes of concentrated hydrochloric acid, 10 volumes

of distilled water and 8 volumes of hydrofluoric acid [40 percent (v/v)].

A-2.1.1.2 Cacotheline solution — 0.10 percent (v/v) cacotheline in distilled water.

A-2.1.2 Method

Place 2 or 3 drops of the etching solution on the glass surface followed by 1 or 2 drops of the cacotheline solution.

In 5 to 10 s purple colour will be seen on the float bath side; otherwise the solution will remain yellow.

A-2.2 UV Method

View the glass surface in a dark room when illuminated by ultraviolet light as shown in Fig. 3. The float bath side exhibits a slight fluorescence.

NOTE — Ultraviolet light in the region 254 nm to 365 nm will damage the eyes and suitable protective UV — filter goggles must be worn.

A-2.3 Energy Dispersive Analysis (EDA) Method

Examine the glass surface by energy dispersive analysis. The float bath side is identified by its tin content.

A-3 PROCEDURE

Calibration of the abrasion apparatus may be performed by measuring either the loss in mass (see A-3.1) or the change in gloss (see A-3.2). Eight float glass test specimens measuring 100 mm × 100 mm shall be

abraded on the float bath side using the abrasive load given in 4.1 of the main text.

A-3.1 Mass Loss

Dry the test specimens in the drying oven at 110 ± 5°C and measure the mass of the each. Abrade the specimens for 6 000 revolutions. Rinse and then dry the test specimens again at 110 ± 5°C and determine the loss in mass of each specimen and calculate the mean loss. Measure the abraded area of each specimen.

The abrasion apparatus is satisfactory, if the mean loss in mass is 0.032 ± 0.002 mg/mm² of the abraded area.

A-3.2 Gloss Change

Measure the 60° specular gloss on the float bath side at the centre of each test specimen backed by a matt black surface (for example, black velvet). Abrade the specimen for 1 000 revolutions. Rinse and then dry the specimens and remeasure the 60° specular gloss. Calculate the percentage loss in gloss for each specimen and the mean loss in gloss.

The abrasion apparatus is satisfactory, if the mean loss in gloss at the centre of the abraded area is 50 ± 5 percent.

If any difficulty is experienced in obtaining stable initial gloss values, the glass may first be cleaned by immersion in water containing a trace of detergent for at least 1 h at 75 ± 5°C followed by rinsing with warm water.

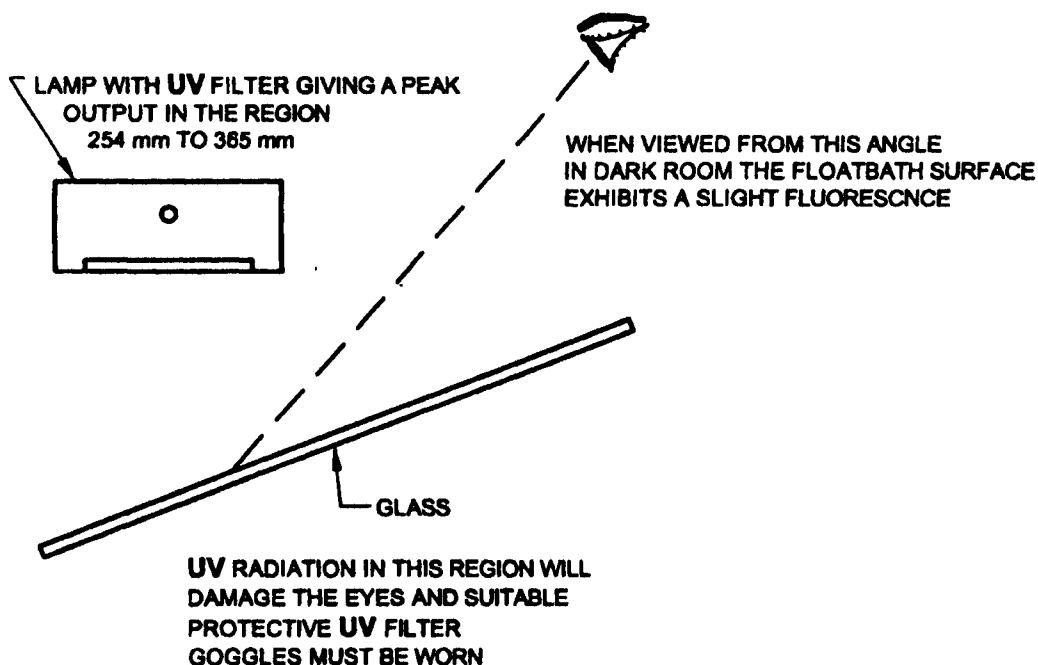


FIG. 3 UV METHOD

*Indian Standard***CERAMIC TILES — METHODS OF TEST,
SAMPLING AND BASIS FOR ACCEPTANCE****PART 12 DETERMINATION OF RESISTANCE TO DEEP ABRASION —
UNGLAZED TILES***(First Revision)***1 SCOPE**

This standard (Part 12) covers a method of test for determining the resistance to deep abrasion of all unglazed ceramic tiles used for floor coverings.

2 REFERENCES

The standards listed below are necessary adjuncts to this standard:

<i>IS No.</i>	<i>Title</i>
2062 : 1999	Steel for general purposes (<i>fifth revision</i>)
11643 : 1985	Specification for silicon carbide for bonded abrasive products

3 PRINCIPLE

Determination of the abrasion resistance of unglazed

ceramic tiles by measuring the length of the groove produced in the proper surface by means of a rotating disc under given conditions and with the use of abrasive material.

4 ABRASIVE MATERIAL

White fused aluminum oxide conforming to the grain size requirement of Grit No. 80 of Table 1 of IS 11643.

5 APPARATUS

5.1 Abrasion Apparatus — It consists essentially of a rotating disc, a storage hopper with dispensing device for the abrasive material; a test specimen support and a counterweight (*see Fig. 1*).

5.1.1 The disc is made of Fe 410-S steel as specified in IS 2062, with a diameter of 200 ± 0.2 mm, and

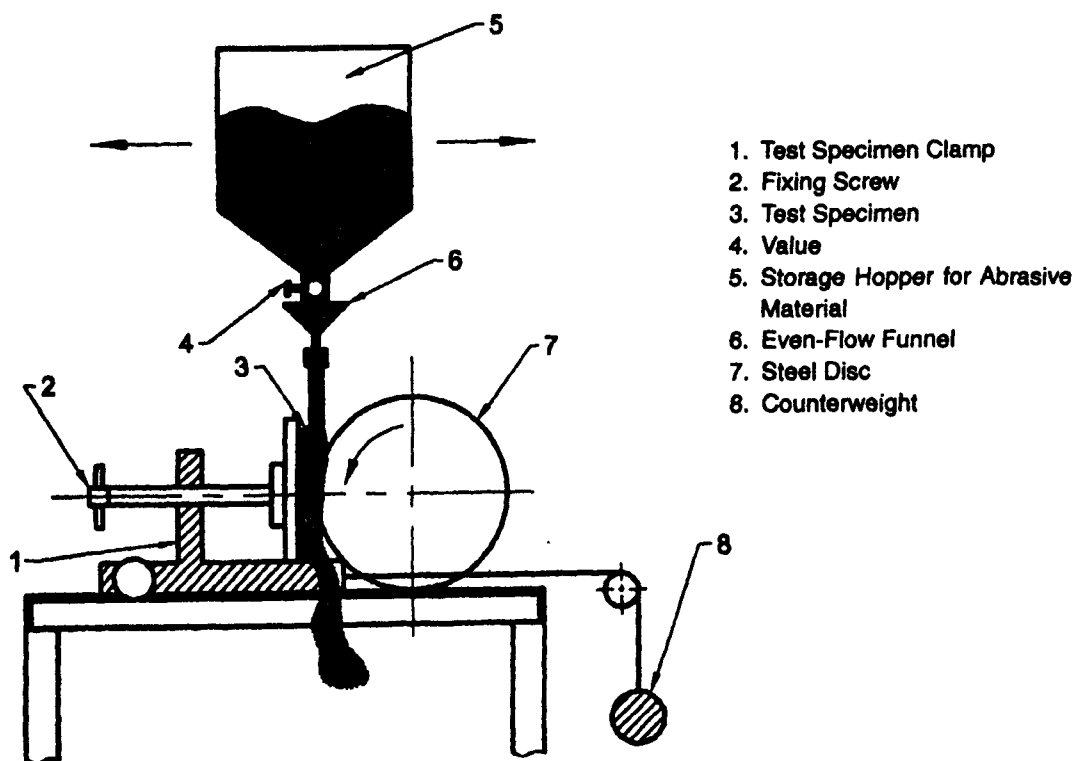


FIG. 1 ABRASION APPARATUS

thickness at the edge of 10 ± 0.1 mm, and with a rate of revolution of 75 rev/min. The pressure with which test specimens are held against the steel disc is determined by calibrating the apparatus against Austrian Standard Granite. The pressure is adjusted such that, after 300 revolutions a chord of 32 mm is produced.

5.1.2 When the diameter has worn to 199 mm, the steel disc shall be replaced.

5.2 A Measuring Gauge — Capable of measuring to 0.1 mm.

6 TEST SPECIMENS

6.1 Types of Test Specimens

Test shall be carried out using whole tiles or test specimens of suitable dimensions. Before testing, small specimens shall be fixed with an adhesive on to a larger background, avoiding joints.

6.2 Preparation

Clean, dry test specimens shall be used.

6.3 Number of Test Specimens

A minimum of five test specimens shall be tested.

7 PROCEDURE

7.1 Place a test specimen in the apparatus so that it is tangential against the rotating disc. Ensure that the feed of abrasive material into the grinding zone is uniform at a rate of at least 100 g/100 revolutions.

7.2 Rotate the steel disc for 150 revolutions. Remove the test specimen from the apparatus and measure the chord length of the groove by means of the measuring gauge to the nearest 0.5 mm. Test each specimen in at

least two places at right angles on its proper surface.

7.3 If relief surfaces would interfere with the determination of the abrasion resistance, the projections may be ground off but the results of the test will not be the same as for tiles having plane surfaces.

8 EXPRESSION OF RESULTS

8.1 The resistance of deep abrasion is expressed as the volume V of material removed, in cubic millimetres. This is calculated from the chord length l of the groove by means of the expression:

$$V = \{(\pi \cdot \alpha / 180) - \sin \alpha\} h \cdot d^2 / 8$$

where

$$\frac{\sin \alpha}{2} = \frac{l}{d}$$

d = diameter of the rotating disc, in mm;

h = thickness of the rotating disc, in mm;

α = angle (in degrees) subtended at the centre of the rotating disc by the chord (see Fig. 2); and

l = length of the chord, in mm.

8.2 Some equivalent values are given in Table 1.

9 TEST REPORT

The test report shall contain the following:

- Description of the tiles;
- Chord length l of each groove to the nearest 0.5 mm;
- Volume V in cubic millimetre, for each individual groove; and
- Average volume V_m , in mm^3 .

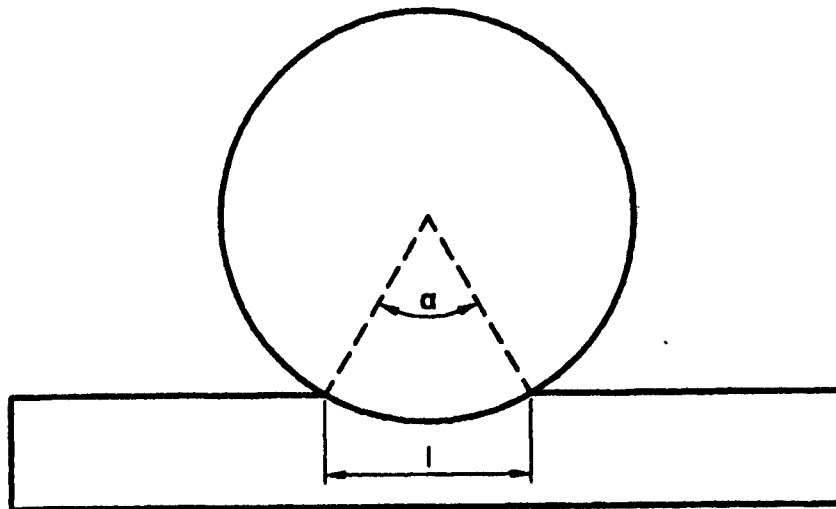


FIG. 2 DEFINITION OF CHORD

Table 1 Equivalent Value
(Clause 8.2)

<i>l</i>	<i>v</i>	<i>l</i>	<i>v</i>	<i>l</i>	<i>v</i>	<i>l</i>	<i>v</i>	<i>l</i>	<i>v</i>
mm	mm ³	mm	mm ³	mm	mm ³	mm	mm ³	mm	mm ³
20.0	67.0	30.0	227	40.0	540	50.0	1 062	60.0	1 851
20.5	72.0	30.5	238	40.5	561	50.5	1 094	60.5	1 899
21.0	77.0	31.0	250	41.0	582	51.0	1 128	61.0	1 947
21.5	83.0	31.5	262	41.5	603	51.5	1 162	61.5	1 996
22.0	89.0	32.0	275	42.0	626	52.0	1 196	62.0	2 046
22.5	95.0	32.5	288	42.5	649	52.5	1 232	62.5	2 097
23.0	102.0	33.0	302	43.0	672	53.0	1 268	63.0	2 149
23.5	109.0	33.5	316	43.5	696	53.5	1 305	63.5	2 202
24.0	116.0	34.0	330	44.0	720	54.0	1 342	64.0	2 256
24.5	123.0	34.5	345	44.5	746	54.5	1 380	64.5	2 310
25.0	131.0	35.0	361	45.0	771	55.0	1 419	65.0	2 365
25.5	139.0	35.5	376	45.5	798	55.5	1 459	65.5	2 432
26.0	147.0	36.0	393	46.0	824	56.0	1 499	66.0	2 479
26.5	156.0	36.5	409	46.5	852	56.5	1 541	66.5	2 537
27.0	165.0	37.0	427	47.0	880	57.0	1 583	67.0	2 595
27.5	174.0	37.5	444	47.5	909	57.5	1 625	67.5	2 636
28.0	184.0	38.0	462	48.0	938	58.0	1 669	68.0	2 717
28.5	194.0	38.5	481	48.5	968	58.5	1 713	68.5	2 779
29.0	205.0	39.0	500	49.0	999	59.0	1 758	69.0	2 842
29.5	215.0	39.5	520	49.5	1 030	59.5	1 804	69.5	2 906

Indian Standard

**CERAMIC TILES — METHODS OF TEST,
SAMPLING AND BASIS FOR ACCEPTANCE**

**PART 13 DETERMINATION OF SCRATCH HARDNESS OF
SURFACE ACCORDING TO MOHS**

(First Revision)

1 SCOPE

This standard (Part 13) covers a method of test for determining the scratch hardness of the surface of all ceramic tiles.

2 PRINCIPLE

Determination of the scratch hardness on Mohs' scale by drawing minerals of defined hardness by hand over the surface.

3 TEST MATERIALS

<i>Material</i>	<i>Mohs' Hardness</i>
Talc	1
Gypsum	2
Calcite	3
Fluorspar	4
Apatite	5
Felspar	6
Quartz	7
Topaz	8
Corundum	9
Diamond	10

4 TEST SPECIMENS

A minimum of three tiles shall be tested.

5 PROCEDURE

5.1 Place the tile under test on a firm support with the glazed or proper surface uppermost.

5.2 Draw over the surface to be tested, by hand, a sharp freshly broken edge of the reference mineral applying a uniform effort such that at the end of the test, its edge or the tile surface is intact.

5.3 Repeat this procedure four times with a sharp freshly broken edge of the reference mineral.

5.4 Repeat the procedure for each tile with each mineral that is necessary to obtain a result.

5.5 Examine the tiles for scratches by naked eye, with the aid of spectacles, if usually worn.

5.6 For each tile note the mineral of highest Mohs' hardness that produce no more than one scratch

5.7 In the case of tiles having variable scratch hardness note the lowest Mohs' hardness.

6 TEST REPORT

The test report shall contain the following:

- a) Description of the tiles; and
- b) Mohs' hardness of each test specimen.

Indian Standard

CERAMIC TILES — METHODS OF TEST, SAMPLING AND BASIS FOR ACCEPTANCE

PART 14 DETERMINATION OF IMPACT RESISTANCE BY MEASUREMENT OF COEFFICIENT OF RESTITUTION

1 SCOPE

This standard (Part 14) defines a method of test for determining the impact resistance of ceramic tiles by measuring the coefficient of restitution.

1.1 Definition

For the purpose of this standard the coefficient of restitution (e) between two impacting bodies is defined as the relative velocity of departure divided by the relative velocity of approach.

2 PRINCIPLE

Determination of coefficient of restitution by dropping a steel ball from a fixed height on to the test specimen and measuring the height of rebound.

3 APPARATUS

3.1 Chrome Steel Ball, of 19 ± 0.05 mm diameter.

3.2 Ball-Release Apparatus (*see* Fig. 1) — Consisting of a heavy steel base on levelling screws with a vertical steel bar to which is attached an electromagnet, a guide tube and test until support.

The test unit is clamped firmly in a position so that the dropping steel ball impinges on the centre of the horizontal tile surface. A clamping device is shown in Fig. 1 but any suitable system may be used

3.3 Electronic Timing Device, which, by means of a microphone, measures the time interval between the first and second impacts when the ball is dropped on to the test specimen. This apparatus is optional.

4 PREPARATION FOR THE ABOVE TEST

4.1 Number of Test Specimens

A minimum of five pieces in dimensions $75 \text{ mm} \times 75 \text{ mm}$ cut from five tiles. Tiles with facial dimensions less than 75 mm may be used.

4.2 Brief Description of Test Units

The test units consist of test specimens fixed to mature concrete blocks by means of rigid epoxide resin adhesive.

4.3 Concrete Blocks

4.3.1 The dense concrete blocks shall be of approximate dimensions $75 \text{ mm} \times 75 \text{ mm} \times 50 \text{ mm}$ and prepared in moulds of this size or alternatively cut from large concrete slabs.

4.3.2 The following method describes the preparation of dense concrete blocks made from gravel/sand, but other aggregates may be used and then the surface water absorption test may not be appropriate.

4.3.3 Concrete block or slabs may be made by adding one part by mass of Portland cement to 4.5 to 5.5 parts by mass of aggregate. The aggregate shall be gravel sand of 0 to 8 mm particle size with a continuous grading curve between the limits *A* and *B* in Fig. 2. The total fines of particle size, below 0.125 mm in the mix of concrete, including Portland cement, should be about 500 kg/m^3 .

4.3.4 The water/cement ratio shall be 0.5. Thoroughly mix the constituents in a mechanical mixer and trowel into moulds of the required size. Compact for 90 s at 50 Hz on a vibrating table.

4.3.5 Condition the slabs for 48 h at $23 \pm 2^\circ\text{C}$ and 50 ± 5 percent relative humidity before removing them from the moulds. Thoroughly rinse off any mould release agent. Throughout the remaining conditioning, the slabs shall be held vertically leaving gaps between them. Immerse in water at $20 \pm 2^\circ\text{C}$ for 6 days, then in air at $23 \pm 2^\circ\text{C}$ and 50 ± 5 percent relative humidity for 21 days. The assembly face of the concrete shall have an absorption of surface water after 4 h in the range of 0.5 cm^3 to 1.5 cm^3 when three specimens are tested in accordance with the method shown in Annex A and Fig. 3.

4.3.6 Blocks subsequently cut from concrete slabs by wet methods require a minimum of 24 h drying at $23 \pm 2^\circ\text{C}$ and 50 ± 5 percent relative humidity before assembly in test units.

4.4 Epoxide Resin Adhesive

The adhesive shall not contain ingredients which increase flexibility. A suitable adhesive consist of

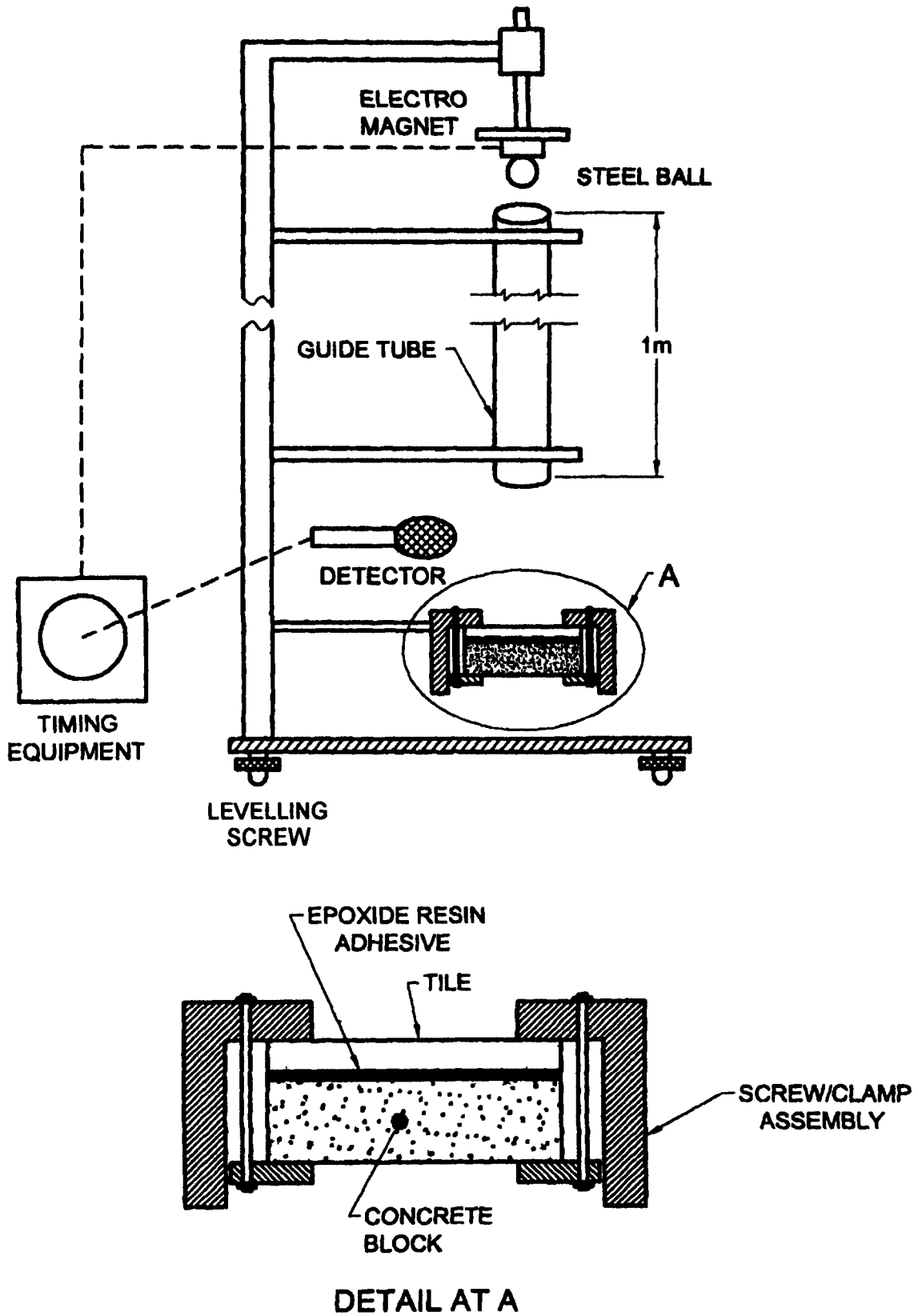


FIG. 1 BALL RELEASE APPARATUS

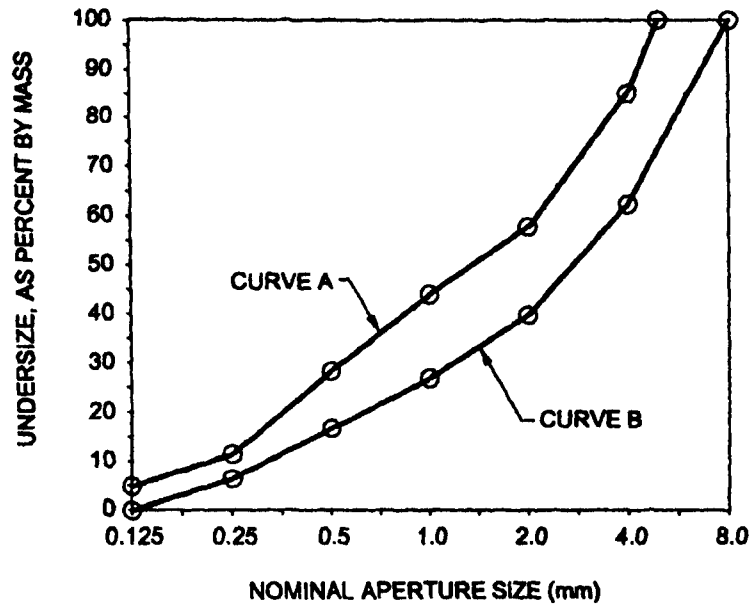
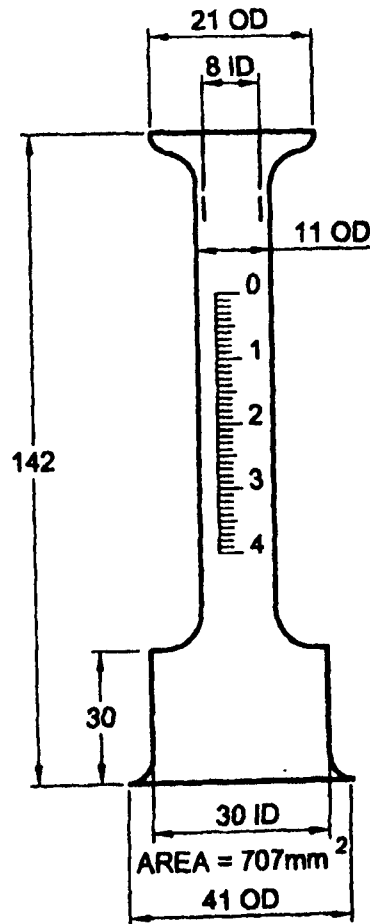


FIG. 2 GRADING CURVES FOR GRAVEL SAND OF 8 mm MAXIMUM PARTICLE SIZE



All dimensions in millimetres.

FIG. 3 APPARATUS FOR MEASURING THE SURFACE WATER ABSORPTION OF CONCRETE BLOCKS OR SLABS

2 parts by mass of an epoxide resin which is a reaction product of epichlorhydrin and diphenylol propane and one part by mass of a curing agent which is an activated aromatic amine. Pure silica filler of average particle size 5.5 mm, measured by the Coulter Counter or other similar methods, is thoroughly mixed with the other constituents in just sufficient proportion to form a mixture that does not flow.

4.5 Assembly of Test Units

4.5.1 Spread about 2 mm thickness of epoxide resin adhesive over the upper surface of a mature concrete block in a uniform layer. Place three 1.5 mm diameter steel or plastics spacer pegs in the middle of three of the sides so that a sufficient amount of each peg projects to allow it to be removed later. Press a test specimen, with the proper face upwards, into the adhesive and scrape off excess adhesive from the sides before gently removing the three spacer pegs. Allow to stand in a temperature of $23 \pm 2^\circ\text{C}$ and at 50 ± 5 percent relative humidity for 3 days prior to testing.

4.5.2 If tiles of less than 75 mm \times 75 mm facial dimensions are to be tested place one tile so that its centre coincides with the center of the surface of the block. Use cut piece of the tile to complete the 75 mm \times 75 mm area.

5 PROCEDURE

5.1 Adjust the ball-release apparatus by means of the leveling screws so that steel bar is vertical. Place the test unit under the electromagnet so that a steel ball-released from the electromagnet will fall onto the centre of a test unit clamped in position.

5.2 Place a test unit in the support with the proper face of the test specimen upwards and horizontal. Release the steel ball from a height of 1 m above the proper face of the test unit and allow it to bounce. Measure the height of rebound by a suitable detector and calculate the coefficient of restitution (e).

5.3 Alternatively allow the ball to bounce twice, note the time between bounces to the nearest millisecond and calculate the height of rebound and hence the coefficient of restitution.

5.4 Any suitable means of measuring the height of rebound or the time interval between the two impacts may be used.

5.5 Examine the surface of the tile for signs of indentation or cracking. All minor Hertzian cracks which cannot be seen from a distance of 1 m with the naked eye or with spectacles if usually worn, should

be ignored. Edge chipping of surface relief should be noted but may be ignored in classifying tiles.

5.6 Repeat the whole procedure for the other test units.

6 EXPRESSION OF RESULTS

For a ball impacting a horizontal static surface the coefficient of restitution

$$e = \frac{v}{u}$$

where

v = velocity of departure (rebound), and
 u = velocity of approach.

If,

h_1 = height of drop, in cm; and
 h_2 = height of rebound, in cm.

Then,

$$v^2 = 2gh_2 \quad \text{and} \quad u^2 = 2gh_1$$

Hence
$$e^2 = \frac{h_2}{h_1}$$

If the height of rebound is determined by allowing the ball to bounce twice and measuring the time interval between bounces the equation of motion is:

$$s = ut + \frac{1}{2}at^2$$

where

s = height of rebound, in cm;
 u = velocity at peak rebound height;
 = zero;
 a = acceleration due to gravity;
 = g (= 981 cm/s²); and
 t = $T/2$, where T = time interval, in s.

Hence

$$s = 122.6 (T^2) = h_2.$$

7 CALIBRATION

Assemble five test units (see 4.5) using 8 ± 0.5 mm thick unglazed B1a tiles (water absorption ≤ 0.08) with plane surfaces. Test in accordance with 5. The average height of rebound (h_2) shall be 72.5 ± 1.5 cm so that coefficient of restitution is 0.85 ± 0.01 .

8 REQUIREMENT FOR PASSING

The normal requirement for light duty installations is a coefficient of restitution of 0.55 and for heavier duty applications; minimum coefficient of restitution of 0.90 is required

9 TEST REPORT

- a) Reference to the Indian Standard,
- b) Description of the tiles,
- c) Coefficient of restitution of each of the five test specimens,
- d) Average coefficient of restitution, and
- e) Any indentation or cracking of test specimens.

ANNEX A

(Clause 4.3.5)

**DETERMINATION OF THE WATER ABSORPTION AT THE SURFACE
OF CONCRETE BLOCKS OR SLABS**

A-1 PROCEDURE

A-1.1 Attach a graduated glass cylinder (*see* Fig. 3) to the concrete surface by means of a suitable sealant around the perimeter of the base. Allow the sealant to cure.

A-1.2 Fill the graduated cylinder to the zero mark with de-ionized or distilled water.

A-1.3 Record the water level after 1, 2, 3 and 4 h and obtain a curve of surface water absorption *versus* time.

A-1.4 Test the surface in 3 specimen and obtain an average surface water absorption after 4 h.

Indian Standard

CERAMIC TILES — METHODS OF TEST, SAMPLING AND BASIS FOR ACCEPTANCE

PART 15 CERAMIC TILES — SAMPLING AND BASIS FOR ACCEPTANCE

1 SCOPE

This standard (Part 15) defines rules for batching, sampling, inspection and acceptance/rejection. It applies to unfixed ceramic tiles that have been stored under cover.

2 REFERENCES

The Indian Standards listed below are necessary adjuncts to this standard:

IS No.	Title
2500	Sampling inspection tables:
(Part 1) : 1992	Inspection by attributes and by count of defects (<i>second revision</i>)
(Part 2) : 1965	Inspection by variables for percent defective
13712 ¹⁾	Ceramic tiles — Definitions, classifications, characteristics and marking

3 PRINCIPLE

This standard provides for a sampling inspection system with a double sampling plan, partly for the method of inspection by attributes (individual values) and partly for a method of inspection by average values (variables). The number of tiles to be tested varies for each property (*see* Table 1).

4 DEFINITIONS

4.1 Order — A quantity of tiles ordered at one time. An order may consist of one or more consignments.

4.2 Consignment — A quantity of tiles delivered during a period of two days.

4.3 Homogeneous (Sub) Consignment — A (sub) consignment that consists of tiles from one manufacturer under conditions and with properties that are presumed uniform.

4.4 Inspection Lot — A quantity of tiles submitted

for inspection manufactured under conditions and with properties that are presumed uniform.

4.5 Sample — A specified number of tiles taken from an inspection lot.

4.6 Sample Size — The number of tiles to be tested for each property.

4.7 Requirement — A required characteristic as specified for the property in the product standard concerned.

4.8 Non-conforming Unit — A tile that does not meet the requirement for the property concerned.

5 CONSTITUTION OF INSPECTION LOT

An inspection lot may consist of one or more homogeneous consignments or homogeneous sub-consignments. Any consignment, which is not homogeneous, shall be divided into sub consignments, which are assumed to be homogeneous and then may constitute inspection lots. If the non-homogeneity is not relevant to the properties to be tested, then by agreement between the supplier and the consumer, the consignment can be treated as homogeneous.

NOTE — For example, a consignment can be homogeneous with regard to dimensions and water absorption of nominally the same body with different glazes and non-homogeneous with regard to surface quality. Also accessories, which differ only in shape from the remaining tiles in the sample may be considered homogenous with respect to other properties.

6 EXTENT OF THE INSPECTION

The choice of properties to be considered for inspection shall be subject to agreement between the supplier and the consumer and may depend on the size of the inspection lot. While all the tests in relation to the technical specification are required to be performed, Table 2 may be used as a guideline to classify the relative importance of each property in relation to the application.

NOTE — In principle a complete range of tests shall only be executed for inspection lots of more than 5 000 m² of tiles. Testing is usually not considered to be necessary for inspection lots of less than 1 000 m² of tiles. The number of inspection lots to be drawn for testing shall be subject to agreement between the parties concerned.

¹⁾ Under finalization.

Table 1 Sampling of Ceramic Tiles
(Clauses 3 and 7.3)

Properties	Sample Size		Inspection by Attribute, If Required				Inspection by Average Value, If Required				Test Method as per IS 13630	
	Initial Number	Second Number	Initial Sample		Initial + Second Samples		Initial Sample		Initial + Second Samples			
			Acceptance Number A_{c1}	Rejection number R_{e1}	Acceptance number A_{c2}	Rejection number R_{e2}	Acceptable if	Second sample to be drawn if	Acceptable if	Rejection justified if		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	
Dimension ¹⁾	10	10	0	2	1	2	—	—	—	—	Part 1	
Surface quality ²⁾	30	30	1	3	3	4	—	—	—	—	Part 1	
	40	40	1	4	4	5	—	—	—	—		
	50	50	2	5	5	6	—	—	—	—		
	60	60	2	5	6	7	—	—	—	—		
	70	70	2	6	7	8	—	—	—	—		
	80	80	3	7	8	9	—	—	—	—		
	90	90	4	8	9	10	—	—	—	—		
	100	100	4	9	10	11	—	—	—	—		
	1 m ²	1 m ²	4%	9%	5%	>5%	—	—	—	—		—
	Water absorption ³⁾	5 ⁴⁾ 10	5 ⁴⁾ 10	0 0	2 2	1 1	2 2	$x_1 > L^5)$ $x_1 < U^6)$	$x_1 < L$ $x_1 > U$	$x_1 > L$ $x_1 < U$		$x_1 < L$ $x_1 > U$
Modulus of rupture ³⁾	7 ⁷⁾ 10	7 ⁷⁾ 10	0 0	2 2	1 1	2 2	$x_1 > L$	$x_1 < L$	$x_1 > L$	$x_1 < L$	Part 6	
Scratch hardness (Mohs)	3	3	0	2	1	2	—	—	—	—	Part 13	
Resistance to abrasion UGL	5	5	0	2 ⁸⁾	1 ⁸⁾	2 ⁸⁾	—	—	—	—	Part 12	
Coefficient of linear thermal expansion	1	1	0	2 ⁹⁾	1 ⁹⁾	2 ⁹⁾	—	—	—	—	Part 4	
Resistance to thermal shock	5	5	0	2	1	2	—	—	—	—	Part 5	
Crazing resistance	5	5	0	2	1	2	—	—	—	—	Part 9	
Chemical resistance UGL ¹⁰⁾	5	5	0	2	1	2	—	—	—	—	Part 7	

Table 1 (Concluded)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	
Chemical resistance GL ⁶⁾	5	5	0	2	1	2	—	—	—	—	Part 8	
Resistance to abrasion GL PEI ¹¹⁾	11	—	When classified according to the PEI method the abrasion class shall be equal to or better than the abrasion class specified by the manufacturer									Part 11
Frost resistance ¹¹⁾	10	—	0	1	—	—	—	—	—	—	Part 10	
Moisture expansion	7	7	0	2	1	2	—	—	—	—	Part 3	
Impact resistance							Attribution by manufacturer's declaration					Part 14

¹⁾ Only for tiles with individual areas $\geq 4 \text{ cm}^2$.

²⁾ At least 1 m^2 with a minimum of 30 tiles. Whatever the number of tiles in 1 m^2 , the test sample should be rounded to the nearest 10 tiles above. Conformity to acceptable quality level (AQL) 2.5% in accordance with IS 2500 (Parts 1 and 2) is an acceptable alternative to the procedure in Table 1.

³⁾ The sample size depends on the size of the tile.

⁴⁾ Only for tiles with individual surface areas $> 0.04 \text{ m}^2$. In the case of tiles weighing $< 50 \text{ g}$ a sufficient number shall be taken so as to form five test specimens, each weighing between 50 g and 100 g .

⁵⁾ L = lower specification limit.

⁶⁾ U = upper specification limit.

⁷⁾ Only for tiles with lengths $\geq 48 \text{ mm}$.

⁸⁾ Number of measurements.

⁹⁾ Number of test specimens.

¹⁰⁾ Per test solution.

¹¹⁾ There is no double sampling test procedure for these properties.

7 SAMPLING

7.1 The place where samplings shall take place shall be subjected to agreement between the supplier and the consumer.

7.2 One or two representatives of each party concerned may be present at the time the sample is taken.

7.2.1 Sample shall be taken at random from the inspection lot.

7.2.2 Two samples shall be taken. It may not be necessary to test the second sample. Each sample shall be packed separately and shall be sealed and marked as agreed by the parties concerned.

7.3 For each property the number of tiles to be tested is indicated as 'sample size' in Table 1.

8 INSPECTION

8.1 The extent of the tiles in the sample shall be executed according to the test methods specified in the relevant standard.

8.2 The test results shall be evaluated according to 9.

9 DETERMINATION OF ACCEPTABILITY OF INSPECTION LOT

9.1 Inspection by Attributes

9.1.1 When the number of non-conforming units found in the initial sample is equal to or less than the acceptance number Ac_1 , indicated in col 4 of Table 1, the inspection lot from which the sample was drawn shall be considered acceptable.

9.1.2 When the number of non-conforming units found in the initial sample is equal to or greater than the rejection number Re_1 , indicated col 5 of Table 1, this justifies rejection of the inspection lot.

9.1.3 When the number of non-conforming units found in the initial sample lies between the acceptance number and the rejection number (see col 4 and col 5 of Table 1), a second sample of the same size as the initial sample shall be drawn and tested.

9.1.4 The number of non-conforming units found in the initial and second sample shall be totaled.

9.1.5 If the number of non-conforming units is equal

to or less than the acceptance number Ac_2 indicated in col 6 of Table 1, the inspection lot shall be considered acceptable.

9.1.6 If the total number of non conforming units is equal to or greater than the second rejection number Re_2 indicated in col 7 of Table 1, justifies the rejection of the inspection lot.

9.1.7 When the relevant Indian Standard calls for more than one properties to be tested, the second sample taken (see 9.1.3) shall only be inspected in accordance with those tests which at the inspection of initial sample gave number of non-conforming units between the acceptance number Ac_1 and the rejection number Re_1 .

9.2 Inspection by Average Value

9.2.1 If the average value (\bar{X}_1) of the test results of the initial samples meets the requirements, the inspection lot shall be considered acceptable.

9.2.2 If the average value (\bar{X}_1) does not meet the requirements, a second sample shall be drawn of the same size as the initial sample (see Table 1 col 10).

9.2.3 If the average value of the (\bar{X}_2) test results of the combined initial and second samples meets the requirements, the inspection lot shall be considered acceptable (see Table 1, col 10).

9.2.4 If the average value (\bar{X}_2) does not meet the requirements, this justifies rejection of the inspection lot. (see Table 1, col 11).

10 FIELD TEST

Following tests which may be carried out in the field are:

- a) Dimensions; and
- b) Surface quality, etc.

11 ACCEPTANCE REPORT

Report with reference to this Indian Standard:

- a) Identification of the tiles;
- b) Sampling procedure;
- c) Constitution of the inspection lot; and
- d) Determination of acceptability for each of the properties tested.

Table 2 Guideline to Classify the Relative Importance of Each Property in Relation to the Application*(Clause 6)*

Characteristics	Floors		Walls		Tests
	Interior	Exterior	Interior	Exterior	Reference to Part of IS 13630
(1)	(2)	(3)	(4)	(5)	(6)
Dimension and Surface Quality					
Length and width	X	X	X	X	1
Thickness	X	X	X	X	1
Straightness of sides	X	X	X	X	1
Rectangularity	X	X	X	X	1
Surface flatness	X	X	X	X	1
Surface quality	X	X	X	X	1
Physical Properties					
Water absorption	X	X	X	X	2
Modulus of rupture and breaking strength	X	X	X	X	6
Resistance to deep abrasion (unglazed)	X	X			12
Resistance to abrasion (glazed)	X	X			11
Linear thermal expansion	X	X	X	X	4
Resistance to thermal shock	X	X			5
Resistance to crazing-glazed	X	X	X	X	9
Frost resistance	X	X	X	X	10
Moisture expansion	X	X	X	X	3
Impact resistance	X	X	X	X	14
Scratch hardness	X	X			13
Chemical Properties					
Resistance to chemicals — glazed	X	X	X	X	8
Resistance to chemicals — unglazed	X	X	X	X	7

X — Required.

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